L. R. 1.

THE

ANNALS

OF

PHILOSOPHY.

NEW SERIES.

JULY TO DECEMBER, 1824.

VOL. VIII.

AND TWENTY-FOURTH FROM THE COMMENCEMENT.

London:

Printed by C. Baldwin, New Bridge-street;

FOR BALDWIN, CRADOCK, AND JOY,

PATERNOSTER-ROW.

1824.

BRITISH MUSEUM
NATURAL HISTORY.
M S D
BRITISH MUSEUM
NATURAL HISTORY BRANCH

TABLE OF CONTENTS.

NUMBER I.—JULY.

Page

Biographical Account of Assessor John Gottlieb Gahn 1
Col. Beaufoy's Astronomical Observations..... 11
Mr. Weaver on the Older Red Sandstone Formation. 11
Mr. South's Corrections in Right Ascension of 37 Principal Stars. 23
M. Bonsdorff on the Chemical Composition of Red Silver Ore..... 29
Mr. Children on the Characters of some Mineral Substances before the Blowpipe..... 36
MM. Ampere and Dulong on M. Rousseau's New Method of measuring the Power of Bodies to conduct Electricity 39
M. Bequerel on the Electro-motive Actions produced by the Contact of Metals with Liquids..... 42
M. Pfaff on a deoxidating Property of the Vapour of Water 45
Mr. Woodward on the Transmission of Electricity through Tubes of Water 48
Mr. Smithson on Mr. Penn's Theory concerning the Formation of the Kirkdale Cave 50
Analytical Account of the Rev. J. Topham's Epitome of Chemistry..... 60
Proceedings of the Royal Society..... 63
———— Linnean Society 63
———— Astronomical Society..... 64
———— Geological Society..... 65
Nature of the free Acid ejected from the Human Stomach in Dyspepsia .. 68
Pyroxylic and Pyroacetic Spirits 69
Argillaceous Iron Ore..... 72
Aberthaw Limestone 72
Composition of Tourmaline..... 72
Petalite..... 73
New Localities of American Minerals 73
On the Cause of the Rotatory Motion of Camphor in Water. 75
Improvement in Clocks..... 76
Method of cleaning Gold Trinkets, and preserving engraved Copper-plates 76
New Scientific Books..... 77
New Patents..... 78
Mr. Howard's Meteorological Journal..... 79

NUMBER II.—AUGUST.

Mr. Powell's Remarks on Solar Light and Heat (*continued*). 81
Sir H. Davy on the Corrosion of Copper Sheeting by Sea Water. 94
Mr. Davies on the Application of Mathematics to Chemical Analysis.... 99

Page
M. Vauquelin's Analysis of the Metal of the Statue found at Lillebonne.. 101
M. Lewenau on Selenium..... 104
Mr. Gray on the Pulmonobranchous Mollusca..... 107
Mr. Chilton on an improved Rain Gauge..... 109
Mr. Brooke on Baryto-Calcite..... 114
Mr. Lewthwaite on the Transmission of Electricity through Tubes of Water 116
Dr. Prout on the Nature of the Acid and Saline Matters in Animals..... 117
Mr. Gray on the Arrangement of Papilionidæ..... 119
M. Berzelius on the Decomposition of Silica..... 121
Ditto on the Mineral Waters of Carlsbad..... 123
Col. Beaufoy's Astronomical Observations..... 141
Mr. Children's Reply to an erroneous Assertion..... 141
Analytical Account of the Philosophical Transactions for 1824, Part I.... 144
Proceedings of the Astronomical Society..... 145
Cystic Oxide..... 146
Note on a Contradiction in Thomson's System of Chemistry respecting Phosphuretted Hydrogen Gas..... 147
Supposed New Metal, Taschium..... 148
Chalybeate Preparations of the London Pharmacopœia..... 149
Zirconia in Black Pepper..... 149
Use of Nitrous Oxide in Eudiometry..... 149
Tartarized Antimony..... 151
Inflammation of Sulphuretted Hydrogen by Nitric Acid..... 151
Urinary Calculus..... 152
Odour of Hydrogen Gas extraneous, Inodorous Hydrogen Gas..... 153
Iodine and Phosphorus..... 153
New Ore of Lead..... 154
Mountain Tallow..... 155
Rare Minerals found in the Vicinity of Edinburgh..... 156
Discovery of Selenium in the Volcanic Rocks of Lipari..... 156
Light and Heat from Terrestrial Sources..... 156
Explosive Engine..... 157
Electricity produced by Congelation of Water..... 157
New Scientific Books..... 157
New Patents..... 158
Mr. Howard's Meteorological Journal..... 159

NUMBER III.—SEPTEMBER.

Biographical Sketch of the late Rev. John Josias Conybeare, MA. MGS. 161
Mr. Herschel on certain Motions produced in Fluid Conductors when transmitting the Electric Current..... 170
Dr. Bostock on the Applicability of Sir H. Davy's Discovery to Copper Vessels employed for Culinary Purposes..... 176
On the different Articles used for Tanning Leather..... 180
Mr. Powell's Remarks on Terrestrial Light and Heat..... 181

Page
M. Berzelius on the Combinations of Acetic Acid with Peroxide of Copper 188
Dr. Thomson's Reply to M. Vauquelin. 203
Rev. J. B. Emmett on an Anomaly in the Combination of Potassium and Oxygen 205
Capt. Beaufoy's Observations made during his Aerial Excursion 209
On the Improved Goniometer of M. Adelmann. (With a Plate.) 212
Remarks upon Mr. Daniell's Work on Hygrometry..... 215
M. Gay-Lussac on the Assay of Chloride of Lime. (With a Plate.) 218
Corrections in the last Number of the Annals..... 226
Proceedings of the Royal Academy of Sciences of Paris..... 227
Means of detecting the Presence of Acetate of Morphia. 228
Cause of the Odour of Hydrogen Gas..... 229
Selenium, an Attendant of Sulphur 230
A Superb Collection of Minerals for Sale 231
New Locality of Tellurium 231
Hydrophobia cured by Acetate of Lead..... 232
Extraordinary Tide 234
Unequal Distribution of Heat in the Prismatic Spectrum..... 235
Distinction of Positive and Negative Electricity..... 236
Description of two Surfaces composed of Siliceous Filaments incapable of reflecting Light, &c..... 236
New Scientific Books..... 237
New Patents..... 238
Mr. Howard's Meteorological Journal..... 239

NUMBER IV.—OCTOBER.

M. Levy on a New Mineral Substance..... 241
Mr. Haycraft on the Heat produced by firing Gunpowder..... 245
Dr. Thomson on Subphosphuretted Hydrogen Gas 247
Mr. South's Corrections in Right Ascension of 37 Principal Stars 248
Rev. J. B. Emmett on the Expansion of Liquids 254
Mr. Patten on a New Air Pump. (With a Plate.)..... 255
Mr. Daniell's Reply to X 257
M. Bussy on the Sulphuric Acid of Saxony 259
Col. Beaufoy on the Construction of Vessels..... 264
M. Breant's Process for making Damasked Steel 267
Mr. Herschel on certain Motions produced in Fluid Conductors when transmitting the Electric Current (*concluded*) 271
Mr. Whipple on Nitric Ether 286
Col. Beaufoy's Astronomical Observations..... 286
Mr. Powell's Remarks on Solar Light and Heat (*continued*) 287
Dr. Wollaston on Semi-decussation of the Optic Nerves..... 294
Dr. Henry's Analysis of some of the Aeriform Compounds of Nitrogen .. 299
Ignition supported by Hydrophosphoric Gas 304
Effect of Prussic Acid on Vegetation 304

Page
To preserve the Colour of Red Cabbage 304
Note on the pretended Alkali of the Daphne 305
On the Production of Liquid Anhydrous Sulphurous Acid..... 307
Organic Analysis by Peroxide of Copper..... 308
Oxalate of Lime decomposed by Potash..... 309
Analysis of Pinite, from St. Pardoux, in Auvergne..... 309
Analysis of Cinnamon-stone, from Ceylon 310
Singular Form of Crystals of Sahlite..... 310
American Localities of certain Minerals and Fossils..... 312
Analyses of Chrysoberyls from Haddam and Brazil 315
Description and Analysis of Sillimanite, a new Mineral..... 315
Extraordinary Extent of the Baize and Flannel Manufacture at Rochdale. 316
Electromagnetic and Galvanic Experiments..... 317
New Scientific Books..... 317
New Patents..... 318
Mr. Howard's Meteorological Journal 319

NUMBER V.—NOVEMBER.

Prof. Cumming on the Use of Gold Leaf as a Test of Electromagnetism. 321
Mr. Herapath on the Solution of $\sqrt[n]{x} = x$..... 322
Col. Beaufoy's Astronomical Observations..... 329
M. Berzelius on Fluoric Acid 330
Mr. South on Mr. Battley's Method of preparing Morphia..... 343
Dr. Henry on some of the Aeriform Compounds of Nitrogen (*concluded*). 344
X's Reply to Mr. Daniell..... 348
Report on Steam-Engines..... 351
Dr. Torry on the Columbite of Haddam (Connecticut) 359
Copper Sheathing..... 362
Dr. Fitton on the Strata below the Chalk, &c. (With a Plate.)..... 365
Juice of Elder Berries as a Test..... 384
Volatility of the Salts of some of the Vegetable Alkalies..... 384
Existence of Manna in the Leaves of Celery..... 385
Iodous Acid 386
Inflammation of a Mixture of Oxygen and Hydrogen under Water..... 387
Advantageous Mode of using Alcohol in Vegetable Analysis..... 387
Garnet..... 388
Meionite..... 389
Erlanite, a new Mineral..... 389
Native Compounds of the Oxides of Uranium and Sulphuric Acid 390
Notice of the Lenzinite from the Neighbourhood of Saint-Sever 391
American Localities of some Minerals 391
Vesuvian Minerals 392
Contractions of Crystals by Heat..... 393
On the Optical Axes of certain Crystals..... 393
On certain Formations deposited from Fresh Water..... 394

Page
Fulminating Powders 395
New Method of destroying Calculi. 396
White's Floating Breakwater 397
Marobia..... 397
New Scientific Books 398
New Patents..... 398
Mr. Howard's Meteorological Journal 399

NUMBER VI.—DECEMBER.

Biographical Sketch of the late Rev. E. D. Clarke, LL.D. 401
Col. Beaufoy's Astronomical Observations..... 419
Mr. Herapath on the Solution of $\downarrow^n x = x$ (*concluded*) 420
M. Gay-Lussac on Conductors of Lightning. (With a Plate.) 427
Mr. Daniell's Reply to X..... 439
M. Lévy on a new Mineral Substance 439
Mr. Moyle on the rapid Descent of the Barometer in October..... 442
Mr. Harvey's Observations on Naval Architecture 443
Mr. Moyle on the Temperature of Mines. 446
M. Berzelius on Fluoric Acid (*continued*) 450
Dr. Fitton's Additional Remarks 458
Letter from Mr. Webster..... 463
Mr. Whipple's Reply to Mr. Phillips. 468
Proceedings of the Royal Society..... 464
———————— Linnean Society 464
———————— Geological Society 465
Minerals produced by Heat 467
Berzelius's Analysis of the Sulphato-tricarbonate of Lead.... 467
Localities of Scottish Minerals. 468
On the Pyro-electricity of Minerals 469
Height of Mount Etna. 472
Mediterranean 472
New Patents..... 472
Mr. Howard's Meteorological Journal. 473
Index , ... 475

PLATES IN VOL. VIII. (*New Series.*)

Plates.	Page
XXX.—Description of M. Adelmann's Improved Goniometer	213
XXXI.—M. Gay-Lussac's Instructions for the Assay of Chloride of Lime	222
XXXII.—New Air Pump.	256
XXXIII.—Dr. Fitton on the Strata below the Chalk, &c.	365
XXXIV.—M. Gay-Lussac on Conductors of Lightning	431

ERRATA.

Page 8, line 44, *for* Constitutionolltokot, *read* Constitutions-Utskott.
71, 28, *for* does yield, *read* does not yield.
129, 38, *for* annexed, *read* unused.
137, 25, *for* No, *read* As.
149, 3, from bottom, *for* nitrous oxide, *read* nitric oxide.
16, from bottom, *for* 1·2, *read* 66.
17, from bottom, *for* 66, *read* 1·2.
167, 24, *for* Clevelly, *read* Clovelly.
198, 41, *for* 27·97, *read* 25·97.
342, 21, *for* act not only, *read* act only.
365, 6 and 14, *for* Raze, *read* Naze.
369, 23, *dele* "and Tetsworth."
374, 16, *for* "and effervescing with acids," *read* "and not effervescing with acids."
376, *dele* the whole of lines 20 and 21. Pinna, &c. and Venus—the specimens here mentioned are of uncertain locality and geological situations.
382, 27, *for* figs. 4 and 5, *read* fig. 3 and 4.
383, 3, *for* are in the green sand, *read* are said to be in the green sand.
389, 28, *for* pearl, and resembles, *read* pearl. It resembles.
447, 19, *for* a true data, *read* true data.

ANNALS

OF

PHILOSOPHY.

JULY, 1824.

Article I.

Biographical Account of Assessor John Gottlieb Gahn.

Among the many illustrious names which have adorned the annals of chemistry during the last fifty years, there are few entitled to a more distinguished place than that of Gahn. Born in the most favoured district of a country which was in the fullest enjoyment of its freedom,—the pupil of Bergmann, and the friend of Scheele, he is alike distinguished as a patriotic citizen, and as a profound philosopher. Identified with the fame of these two celebrated men will Gahn's descend to posterity, for it was in their publications that his greatest discoveries made their first appearance; and in the hearts of all his countrymen will his memory live embalmed, by the recollection of his general philanthropy and public virtue. Nor was he less amiable in private life; but, with the generosity of a liberal mind, he freely and frankly communicated on all occasions the boundless store of information which he had acquired, or the practical application of the discoveries which he had made. By his improvements in the arts of mining and metallurgy, he increased the wealth, not less than the glory of his country; and at this day, there is no name more admired, and at the same time more beloved, in Sweden, than that of John Gottlieb Gahn.

On the 17th of August, 1745, at the Woxna Iron Works, in South Helsingland, was born J. G. Gahn, son of Hanns Jacob Gahn, Treasurer to the Government of Stora Kopporberg. In his 15th year he had completed his preparatory education at the Gymnasium of Westeras, and early in the year 1760, he commenced his scientific studies in the University of Upsala. His mind seems already, even at this period, to have received the bias towards those pursuits which continued the study of his manhood and of his age, and which will long preserve his memory from decay. The wide fields of mineralogy and chemistry, of mathematics and mechanical philosophy, here

engaged his young and eager spirit. He was one whose ardour, while it bore him rapidly forward, did not permit him carelessly to pass over any thing; and that vivacity of disposition which directed his attention to so many and various objects in rapid succession, was but a guide to him, though it must have bewildered others. He was one of the few who can run and read, and turn to account, accidents, and even blunders, of the most fortuitous description.

Thus it happened to him, while yet a pupil in the Academy, that a specimen of crystallized carbonate of lime dropped from his fingers. It was of the variety which mineralogists term dog's-tooth spar, and the fall shattered it into fragments. While gathering these up, Gahn's attention was arrested by the appearance which one of them presented, and in which a portion of the original nucleus had been developed by the accident. This hint, which another might have neglected or misunderstood, he immediately followed up; nor did he rest satisfied until he had extracted by cleavage the rhomboid which constitutes the primitive form of this mineral, from a great variety of its secondary crystals. Bergmann, to whom this observation and discovery were communicated, published, immediately afterwards, a Dissertation on the Forms of Crystals, which called forth the well-merited admiration of men of science. But while Bergmann reaped this honour from his Essay, he had omitted to mention, that it was the discoveries of the pupil, which had furnished the basis of all the reasonings of the master.

The next important service which the subject of this memoir rendered to science, was the investigation of the nature of the earth of bones. In this discovery accident had no share; yet it too yielded the first-fruits of reputation to another than the true owner. It is indeed to be regretted that in too many instances, Gahn suffered others to claim and to enjoy the reputation of improvements which they had never made, and of merit which they had never earned. In this he was so negligent during his life, that, it is to be feared, many of his discoveries are at this moment ascribed to others, and can now never be vindicated for their real author. For this strange indifference to fame, permitting others to reap where they had never sown, it is not easy to account; though we have an instance of something similar in the conduct of another celebrated chemist, Dr. Black, who, after finding the tract, and clearing the way, to a most fascinating field of discovery, contented himself with sitting down at the barrier which his genius had overthrown, while others passed by, and gathered an easy harvest of reputation.

Previously to this period, the earth of bones had been universally considered to be *sui generis* and peculiar. Gahn, however, succeeded in analyzing it, and in establishing it to be a neutral salt, composed of phosphoric acid and lime. This is a disco-

very, the value and difficulty of which, none but chemists thoroughly acquainted with the practical department of their science can appreciate. It reflects, however, no little honour on the sagacity of its author; and it has happened, at a period long subsequent to the time when the composition of this earth, as appearing in the animal kingdom, had become familiar to chemists, that the same substance, occurring in the mineral kingdom, has been again and again mistaken for a new and simple earth, by analysts of considerable celebrity.

Just about this time, Scheele had completed his investigation of fluor spar and its acid, and at the conclusion of the treatise which he published on this subject, he informed his readers, that "in addition to the discovery of a new earth, it was also in his power to announce to them that the earth of bones, instead of being an uncompounded substance, is phosphate of lime." The general and ambiguous nature of this allusion to the disco very of Gahn, although wholly unpremeditated on the part of Scheele, was the cause of the credit of it being immediately attributed to him; especially as Gahn had not then so far completed his experiments as to consider them deserving of being laid before the public in a separate memoir. Nor did such a production of his ever after appear; for it was one of the characteristics of his comprehensive genius, that he was ever reluctant to commit any of his opinions or discoveries in a crude state to the press, and where others imagined that little material remained to be investigated, he saw further, and still experienced a painful sense of imperfection.

Gahn next succeeded in demonstrating the metallic nature of manganese, which he effected by exposing its oxide along with charcoal powder to an intense heat. This discovery, however, with many others of inferior moment respecting the more recently known metals, was never published by himself, but appeared originally in the chemical dissertations of Bergmann. Nor is there any one trait in the whole character of our chemist more remarkable than that to which we have already alluded, his indifference to celebrity. He rarely, even in private, narrated in an unreserved manner the progress of any of his discoveries, and the person to whom such a communication was made might regard it as the strongest evidence of his full and confiding friendship. The feeling of how much remained to be done, appearing full before his penetrating eye, seems to have overpowered too much the satisfaction and complacency which ought to have resulted from what had been accomplished. And so forcibly did this sense of imperfection oppress him, that a morbid delicacy has in too many instances deprived the world of the results of his unwearied research during the long period of fifty years. In all this time, scarcely any publication of his appeared until he had almost literally obeyed the injunction of

the poet, in revolving it again and again in his mind, year after year. Yet advantageous as the severe rule of "nonum prematur in annum" may be to poets and their productions, it is by no means applicable to philosophers and their discoveries; and if the friends of Gahn had but been more generous in acknowledging whence they drew their own information, we must have been more heartily grateful to them for communicating it to others, and thereby, not unfrequently, securing a benefit which might else have perished.

Besides those discoveries which resulted from the investigations of Gahn, he conferred a favour of yet greater practical importance on science, in the improvements which he made as the means of prosecuting research. During his youth, the blowpipe was little used by men of science, and its advantages were less understood. That instrument, by which they are now enabled to make microscopic analyses in the dry way, with a degree of precision then wholly unexpected, was in its rude state at that period, more used by the mechanic than by the chemist. Cronstedt and Engerstrom first discovered its importance in distinguishing minerals by their various degrees of fusibility, and their several habitudes with fluxes. Next, Bergmann, by his excellent Dissertation de Tubo Ferruminatorio, extended the knowledge of the instrument more widely, and explained its uses more fully to the learned world. Gahn had been employed by this philosopher to make the greater part of the experiments detailed in the Dissertation, and, from that period, the improvement of every thing connected with the nature or management of the blowpipe, became one of his most favourite occupations. He enlarged, and at the same time defined, the uses of the several reagents; he added some new ones of great importance to their number; he invented or improved the various apparatus accompanying the instrument; and by his almost intuitive sagacity in detecting the characteristics both of simple bodies and of compound minerals, he was enabled to point out at once the plainest and most efficacious means by which they may be discovered and discriminated. A concise summary of directions for using the instrument was drawn up by him, and published in the second volume of Berzelius's Elements of Chemistry.

Another important facility contributed by Gahn to the prosecution of research, deserves to be classed with that just mentioned, and is, perhaps, scarcely inferior to it in value. This was the invention of a balance, not more remarkable for its extreme delicacy, than for the simplicity of its construction. The latter quality it possesses in so remarkable a degree, that it may be easily constructed by any workman of even very moderate qualifications; and thus this elegant and indispensable instrument was placed generally within the reach of all. A very copious description of it was written out by the inventor, a few

months before his death, and was inserted, with his permission, in the same work of Berzelius to which we have just alluded.

Such are a few of the discoveries and inventions of Gahn; but although these may, perhaps, be the chief means of spreading his name abroad, they do not form the character by which he is best known at home. To have a just idea of the man, one must be informed, that the sciences, however much the subject of his fond pursuit, were not at any time his principal occupation, but merely formed an agreeable relaxation, in which he occasionally indulged, when he could spare a few moments from his more serious avocations. Let us now trace the course of his life as a man of the world, and as a man of business, and glance at the public duties he had to discharge as a member of the representative body of Burghers in Sweden, and we shall then feel how surprising is his eminence as a man of science.

On the death of his father, he was left a young man, in narrow circumstances, which compelled him to direct his immediate and almost exclusive attention to the practice of mining and metallurgy. His mode of mastering his profession was characteristic of the man. He was not satisfied, like many others, with a mere theoretic knowledge of its processes, but determined to acquire a thorough acquaintance with them by personal experience. He, therefore, associated with the ordinary miners, dwelt with them, and accommodated himself to their habits, and took an active share in all their labours; nor did he relinquish this mode of life, until it ceased to make additions either to his knowledge, or to his experience.

In the year 1770, he defended at Upsala an academic thesis, entitled "Remarks on Regulations for an improved System of Management in Iron Founderies;" and in the course of the same year, he acquitted himself in the customary examinations respecting his metallurgic knowledge, with an ability which received the unqualified admiration of the judges. A few months after this, he was commissioned by the College of Mines to institute a course of experiments with a view to improve the method of melting copper at Fahlun. The consequence of this investigation was a complete regeneration of the whole system, so as to gain much time and save much expense by the change. Till this period, the old reverberatory furnace was everywhere in use, in which a large proportion of the fuel consumed was altogether wasted. Gahn recommended a new construction, by which this superfluous expenditure is avoided. It was immediately adopted, and continues at this day to be universally employed.

From the intimate acquaintance which he possessed with every subject connected with mining or with metallurgy, it may be imagined that Gahn now felt a strong desire to have the direction of a smelting work of his own. This, however, required a capital which he had not at command; but his reputa-

tion and talents easily procured for him a partnership in some extensive works at Stora Kopporberg; where he settled as superintendant. He had not remained long in this situation when an opportunity occurred, requiring all the experience and skill of which he was master. The contest for the independence of America had just about this period commenced, and as the application of copper to the sheathing of ships had then been but recently introduced, it may be remembered that some of our great merchants entered into extensive speculations on the article of copper, purchasing up the whole which was then in the country, and that many of them realized princely fortunes, by the prodigious advance at which they disposed of the commodity. The demand was great and sudden, the ordinary supply comparatively inadequate to the emergency of the case, and the scarcity and price of the copper rose proportionally. In circumstances such as these, the smelters at Fahlun received an order for sheet copper and copper bolts for the sheathing of ships, of so great an extent, and called for by so early a day, that the men of greatest experience among them conceived its execution to be chimerical. Gahn came forward in this emergency, and undertook, at his own risk, to execute the order within the time prescribed. He was completely successful; thus at once supplying the wants of another country, and greatly raising the reputation of his own. It may well be imagined that his firmness in coming forward on this crisis, though opposed to all the rest of his profession, and his success in proving that he had not overrated his abilities, must have been highly gratifying to himself, and could not fail to bear his reputation through the country.

From the year 1770, when Gahn first settled at Fahlun, down to 1785, he took a deep interest in the improvement of almost all the chemical works in that place and the neighbourhood. In conjunction with the proprietors of the copper mine, he established manufactories of sulphur, sulphuric acid, and red ochre. From the skill of the projector, these immediately became superior to their rivals, on account of the excellence of the articles prepared in them, and they constituted for many years a source of great emolument to their proprietors. But although he thus directed his peculiar attention to the works under his own care, his improvements upon the whole economy of the smelting and refining of the ores, were calculated to be a source of riches to the country, not merely to the individual; and Gahn accordingly, in a liberal and generous spirit, fostered the amendment of the processes in every chemical work in his neighbourhood. It may be said indeed with truth, that there were few chemical manufactories, and in particular that there was not a single work connected with the smelting of copper, in the vicinity of Fahlun, which did not receive a thorough reformation, either from his scientific knowledge, or from his practical skill. Among his

mechanical contrivances, we may mention here an ingenious piece of machinery erected under his superintendence at Awesta, for the purpose of laminating metals, by making them pass between cylindrical metallic rollers.

Such eminence as this could not fail to procure celebrity to Gahn, and conduct so generous on his part destroyed every trace of jealousy. Fame, in general, brings with it envy, because men too often become proud and assuming, in proportion as they become famous. As these qualities, however, formed no part of Gahn's character, it is believed that few men have more enjoyed that mixture of attachment and respect which is called esteem; and testimonies of this flowed in upon Gahn from every quarter.

In the year 1780, the Royal College of Mines, as a testimony of their sense of the value of Gahn's improvements in the general economy of their whole system, and of his successful discharge of every duty which had devolved upon him, presented him with a gold medal of merit. In 1782, he received a royal patent as mining master. In 1784, he was elected a member of the Royal Academy of Sciences; and, in the course of the same year, he was appointed assessor in the Royal College of Mines, in which capacity he officiated as often as his other avocations permitted him to reside in Stockholm.

Nor can we here omit another event which happened to Gahn in the course of this year, since, if it be of little note to him as a public character, it influenced the whole of his domestic happiness. It was in the year 1784 that his marriage took place, when he espoused Anna Maria Bergstrom, with whom afterwards during the long period of thirty-one years, he enjoyed a life of uninterrupted domestic happiness. The fruits of this marriage were a son and two daughters.

We have already adverted to the demands which were made on the Fahlun smelters for copper for the sheathing of ships. All copper, however, is not equally suitable for this end, and indeed some kinds of this metal which might serve excellently for almost any ordinary purpose, if applied to this, undergo corrosion from the action of the sea water to such an extent, as to make them quite unfit to afford the protection which alone renders them valuable. Out of these circumstances a case arose, in which the information and ability of Gahn found an extraordinary opportunity for their exercise, and proved of signal service to his country.

In the year 1773, he had been elected a chemical stipendiary to the Royal College of Mines, and he continued to hold this appointment till the year 1814. During the whole of this period, his information on every subject connected with chemistry was confessedly so superior to that of his associates, that the solution of almost every difficult problem, remitted to the

College, naturally devolved upon him. An interesting and important one was thus committed to him, which occupied him during a series of investigations, prosecuted in the years 1803, 1804; and as the circumstances are interesting, and the result proved highly honourable to Gahn, we shall make no apology for detailing them.

It happened that the copper sheathing of a vessel, after a long voyage in the Mediterranean, had been corroded to an extraordinary extent by the action of the sea water; and a strong but wholly unfounded prejudice had from this circumstance arisen against the employment of Fahlun copper for the sheathing of vessels. Gahn was commissioned to investigate whether there were any grounds for this prejudice, and to suggest, if necessary, such alterations as might remove them. In the elaborate memoir which he drew up on this subject, he demonstrated, in the most decisive manner, that the Fahlun copper contained none of the pernicious admixtures, which render that metal subject to corrosion by sea water. And as a singular proof of the truth of his conclusions, it deserves to be mentioned, that it was discovered upon examination, that the copper sheathing of the vessel in question had not been obtained from Fahlun.

We have now glanced at a few of the benefits conferred by Gahn upon science by his discoveries; upon scientific men by his inventions to facilitate their researches; and upon his country by his improvements in those arts which constitute so great a portion of her wealth. But we should still underrate the character of the man were we to omit mentioning that he was besides a zealous guardian of the rights of his countrymen, in the representative body of which he was repeatedly a member, and that in private life he was not more agreeable to his friends by his urbanity and frankness, than useful to all by his enlightened humanity. In proof of the latter characteristic we may mention, that the first charitable institution for the maintenance of the poor at Fahlun was indebted entirely to his exertions for its establishment.

The privileges entrusted to his more peculiar and local care were of no ordinary kind. Being a member of the Mining Directory of Fahlun, he was by them returned to the representative body of Burghers in the Diets of 1778, 1809, and 1810; and in the momentous discussions which took place in these two latter years particularly, he was always an active member of the Constitutional Committee (Constitutionolltokott). When it is recollected that Dalecarlia in particular, and the whole mining districts of Sweden in general, remained, throughout a long succession of ages, in the unchanged possession of their ancient privileges and local constitutions, notwithstanding the many surprising revolutions which have characterised the Swedish

government from its remotest history down to the latest periods, it will at once be conceived that to Gahn were committed the most valuable and the most ancient privileges in Sweden. It was in the districts just mentioned, that the primitive race of men were found, whom neither the steel of their enemies had subdued, nor their gold had corrupted, and who sallying forth under Gustavus the Great, freed their country from the slavery of a foreign yoke; immediately after which, they returned unaltered by cities or by courts to their former laborious occupations. Services of this nature, which they more than once rendered to Sweden, joined to the great national importance of their occupations, caused numerous privileges to be conferred on the body of miners in general; and, once conferred on characters so determined, it was dangerous to talk of infringing on them. Such was the district with which Gahn in the Diet was more immediately connected, and such were the privileges which fell to him more especially to defend. And they found a champion worthy of the trust; for there is not at this moment one trait in Gahn's history which more endears him to his fellow countrymen, than the ardour and the disinterestedness with which he defended as a Burgher their public rights.

For the last twenty-five years of his life, his country made frequent calls upon his information as a man of science, and upon his experience as a man of business. In 1795 he was chosen a member of the Committee for directing the general Affairs of the Kingdom (Rikets Allmanna arenders beredning); in 1810, he was made one of the Committee for the general Maintenance of the Poor; in 1812, he was elected an Active Associate of the Royal Academy for Agriculture; and in 1816, he became a member of the Committee for organizing the Plan for a Mining Institute. In 1818, he was chosen of the Committee of the Mint; from this situation, however, he was shortly after, at his own request, permitted to withdraw.

In short, genius and talent seem never to have been better bestowed than on Gahn; for through the whole course of his long life, it is difficult to say, whether they procured to him greater celebrity, or to his country greater advantage; whether he was more remarkable for the comprehension and scope of his views, or for the industry and research of his investigations. When the Board of Iron Founderies at Fahlun instituted a series of trials with respect to the melting of cast iron in small furnaces, the experimenters were deeply indebted to the advice and instruction of Gahn. And when, more recently, another set of experiments relative to hydraulic machinery were prosecuted, the same aid was freely administered by the same hand. Thus we find Gahn distinguished as a philosopher in exploring and unveiling the relations of nature; we find him as a mechanical genius, improving and perfecting the blowpipe and the balance

to enable followers in the track of philosophical investigation to clear a path for themselves; we find him superintending the agricultural interests of his country, and increasing her revenues by the improvement and simplification of the process of smelting the ores; we find him guiding the charity of his country; we find him in public the enlightened and zealous patriot, and in private, the steady and agreeable friend, filling honourably and in happiness the relations of husband and of father.

There remains only the end of such a man: it was quiet and serene, the natural consequence of a well-spent life. From the period of his wife's death, which occurred about three years before his own, his health, which had never been robust, visibly declined. Occasionally nature made an effort to shake off the disease, which, however, constantly returned with increasing strength, until, in the autumn of 1818, the decay became more rapid in its progress, and more decided in its character; and he gradually grew weaker and weaker, until on the 8th of December of that year, a calm and peaceful death freed him from all earthly care.

Let it not be supposed that in the above short sketch, we have been able even to glance at all the departments of science and art which own a benefactor in Gahn. Towards the close of his life, his taste, or rather passion, for chemistry and mechanics became more and more decided; but his many calls of public duty rendered it impossible for him to indulge in these his favourite pursuits. It is partly to this circumstance, partly to the extensive variety of subjects to which he turned his eager attention, and in all of which his constant aim was some end of practical utility; and it is in part to be ascribed to his reluctance to publish any speculations not sufficiently matured to please his sensible and delicate mind, that in his death, the world at large, as well the men of science as the men of business, have suffered a misfortune which is irreparable; for his experiments were so various, and his notes and manuscripts so numerous, that it is too much to be feared none other than himself could understand either their arrangement or detail. Of the extent of the loss which is thus sustained, we can only judge by the benefit which has accrued to so many sciences from the source now closed for ever. Of his improvements on the blowpipe, we have already spoken; yet of Gahn's mastery of that instrument, none, except those who saw him use it, can judge: besides this, the art of dyeing; the preparation and application of varnishes; the invention and improvement of implements and tools; &c. all occupied his attention, and received amelioration at his hands. And again, we are forcibly struck with a feeling of wonder, that the same man should be thoroughly master of so many, so various, and so extensive departments of science and art, at one moment. To sum up the whole, we may safely say, that he was

alike eminent as a practical chemist and mechanic, as a patriot in public, and a friend in private life, as presiding over the interests of the miner and of the farmer, and in fine as the guardian and overseer of the large family of his native poor. It will not indeed be easy to find another, whose talents have been at once more brilliant and more useful, who has been more admired and more loved by his country, than John Gottlieb Gahn.

Article II.

Astronomical Observations, 1824.
By Col. Beaufoy, FRS.
Bushey Heath, near Stanmore.

Latitude 51° 37′ 44·3″ North. Longitude West in time 1′ 20·93″.

June 9. Occultation of a small star by the moon. Immersion } 14h 25′ 00″ Siderial Time.

Article III.

Additional Remarks on the Older Red Sandstone Formation, or Group, of foreign Geologists, and the Carboniferous Series of the English. By Thomas Weaver, Esq. MRIA. MRDS. MWS. MGS. HMBI.

(To the Editor of the *Annals of Philosophy*.)

SIR, *Tortworth, June* 1, 1824.

The rapid progress that geology has made within some years past, may be mainly attributed; first, to the greater precision introduced into the researches of geologists, and the consequent greater accuracy of their descriptions; and secondly, to the comparisons which they have thus been enabled to draw between classes and groups of formations, in different parts of the world. The ground-work has thus been laid for correct generalization. Most of the errors that have crept into geology have confessedly proceeded from a hasty desire of deducing general inferences from imperfect or merely local data, without taking that enlarged view of the subject, which, comprising all the modified details observable in different countries, secures alone a safe foundation for legitimate induction. The spirit of inquiry which has gone forth has led to discussion, and to that conflict of opinion in which zealous minds are prone to engage, when instigated by a sincere desire of eliciting the truth. Continental and English geologists thus mutually assist in elucidating the positions of each other. An instance of the kind may, perhaps, be found in the more exact determination of the relative position, characters, and organized remains of the muschel-kalk and quadersandstein of Germany, and other parts of the Continent, from which, so far as they have lately been investigated, there appears reason to

think that they constitute formations that are distinct from, and wholly wanting in, the geological series of England; being in the order of succession interposed between the new red sandstone and the lias limestone. For the clearer development of this position, so far as it has proceeded, we are in a great degree indebted to the active researches of Dr. Boué. Further researches, however, seem to be required before this question can be considered as satisfactorily and definitively settled, inasmuch as the terms muschel-kalk and quadersandstein have both been avowedly very loosely applied in different parts of the Continent. But at present, I confess, I rather lean to the view of the subject entertained by M. von Humboldt and Dr. Boué.

The preceding remarks may not appear wholly inapposite as a preliminary to what I am about to offer.

In presenting in an English dress, and in a compendious form, a Selection from the Annales des Mines of a number of very valuable geological memoirs, Mr. De la Beche has performed a most acceptable service to the British public; and the interesting geological map of France and of the adjoining countries, constructed by M. Omalius d'Halloy, and prefixed to the work, forms a very appropriate introduction, being also convenient as a subject for general reference. The book, I doubt not, will shortly be, as it justly deserves, in the hands of every British geologist.

In this map, M. Omalius d'Halloy has distributed the whole of the formations, which constitute the crust of the globe, into six groups, which (taken in an ascending order) are as follows:

1. The primordial, comprising the primary and transition rocks.
2. The todte liegende or red sandstone group.
3. Comprising the zechstein (magnesian limestone), new red sandstone, muschel-kalk, quadersandstein, and oolite formation.
4. The iron and green sand, and chalk formation.
5. The formations posterior to the chalk, whose aqueous origin is not doubted.
6. Comprising all basaltic and trachytic rocks, and the products of existing volcanos.

In this order of arrangement, the todte liegende or red sandstone group (occupying the position of the carboniferous series), is distinguished by Mr. De la Beche both on the map, and generally throughout the work, as identical with a new red sandstone conglomerate. Yet the documents contained in this book alone not only afford a direct confutation of that statement, but it will be seen that in the construction of the text, Mr. De la Beche is, on this point, at variance with himself.

It is important that this subject should be placed in its true light, for where authorities are balanced against each other, it becomes the more necessary that facts alone should be allowed to preponderate.

It might indeed be supposed from the structure of the map that the group in question was intended by its author to represent the carboniferous series; and such will clearly be found to be the case, if we compare the corresponding coloured districts with the memoirs which tend to elucidate them, whether relating to France, or to Germany. See the memoir of M. Omalius d'Halloy in illustration of his map; that of M. de Bonnard on the Geology of the Western Part of the Palatinate; of M. von Hoff on the Thuringerwald; of M. Beaunier on the Coal District of St. Etienne; of M. Le Chevalier du Bosc on the Coal Mines of the Basin of the Aveyron.*

It will be sufficient for our purpose if we confine our attention to the memoir of M. de Bonnard on the Palatinate, selecting such parts as bear immediately on the question, and adding a few observations.

P. 220, et seq. "The mountainous country on which I propose to offer some geological remarks, is limited on the west and north-west by the course of the Brems and that of the Nahe on the south by the frontier of France; on the east by the prolongation of the Vosges chain to the foot of Mont Tonnerre; lastly, on the north-east by a curved line passing within the limits of the small towns of Gælheim, Alzey, Wællstein, and Creutznach."

"On the left bank of the Nahe, and at a short distance from its bed, the schistose and compact quartzite formations commence, which form the mountains of the Hundsruck. On the right bank, and also at a short distance from the river, are situated the coal measures and red sandstones of the Palatinate."

"The Hundsruck, bounded by the Rhine, the Moselle, the Sarre, and the Nahe, forms part of the great schistose zone which is prolonged from the department of the Ardennes across the north of Germany, and which appears in a great measure composed of transition rocks. The red sandstones of the Pala-

* In a former memoir on the North of France and the adjacent Parts of the Netherlands (Journal des Mines, vol. xxiv), M. Omalius d'Halloy had erroneously applied the term rothe todte liegende to the gypseous and saliferous red sandstone which is found in Luxemburg, extending toward the Sarre, &c. But in the present map, and in the memoir by which it is accompanied, the saliferous or new red sandstone is placed in its correct position, while the term rothe todte liegende is employed in the appropriate German sense.

There is, however, unfortunately, one great inconsistency in the map, upon which Mr. De la Beche has justly remarked; the carboniferous series of the north of France and of the Netherlands being, in conformity with the former view of M. O. d'Halloy (Journal des Mines, vol. xxiv), included in the transition series.

It is also to be regretted that in the construction of the map, so important a group as the carboniferous series should in several cases have been wholly omitted, e. g. in Germany, in the tract extending from the Hartz to the banks of the Saale, that adjacent to the river Ruhr; in France, on the Loire between Angers and Nantes; at St. Litry, south-west of Bayeux, &c. Their distinct introduction, wherever omitted, would have added to the value of the map, however small the scale might have been. The same indeed may be said of other groups, the scale of which, as omitted, must also necessarily have been small.

tinate join on the E those which constitute the mountains of the whole northern part of the Vosges, the eastern slope of which is rapid, but which gradually declines to the W toward the country which especially forms the subject of this notice. In this chain, the granite, long hid beneath the secondary rocks, appears for the last time between Landau and Annweiler; it there forms near Alberschweiler an isolated mountain, in which the granite rock is seen to pass into porphyry. This mountain rises in the midst of the red sandstone that surrounds it, and which immediately rests upon it. Proceeding from this place toward the N to the foot of Mont Tonnerre, or toward the W to Sarrebruck, red sandstones and quartzose conglomerates are only found, the whole of which is commonly known by the name of the red sandstone formation. They are covered, but only in a few points, in this direction, by horizontal shelly limestone (muschel-kalk), as at Bischmissheim, near Sarrebruck, or by limestone and marly clay, as in the environs of Deux Ponts, or by gypsum placed between the red sandstone and limestone, as at Omersheim, between Sarrebruck and Bliescastel. Not far from Sarguemine, on the right bank of the Sarre, is situated the small *saline* of Relchingen, near the limit common to the red sandstone of the Palatinate, and the horizontal limestone of Lorraine. Still more west, the red sandstones envelope the southern part of the coal measures, are prolonged on the left bank of the Sarre, to and beyond the environs of Treves, and even penetrate on the right bank of this river, into the basin of the Brems and its confluents. They are also, in some points, covered with horizontal limestone, as at Nalbach (two leagues to the north of Sarre Louis), at Wahlen (between Mergiz and Wadern), &c. It is probable that this great mass of arenaceous rocks comprises the two formations of red sandstone, known in Germany by the names of rothe liegende and bunter-sandstein;" meaning by the former, the ancient red sandstone, and by the latter, the new red, or variegated, or saliferous sandstone. That such is the interpretation to be given, the preceding description has partly tended to show, the old red and new red sandstones appearing in some places in direct contact with each other, and the new red sandstone partly overlying also the coal measures. But the relative position of the old red sandstone itself is completely established by what follows.

"The coal measures form a zone which extends from SW to NE, 25 leagues in length, from the southern bank of the Sarre, a little below Sarrebruck, to beyond the Nahe in the environs of Sobernheim. The breadth of this zone of coal varies from four to seven leagues, according as it is more or less confined by the two chains between which it occurs. At about a third of its width, it is traversed by a band of the red sandstone formation, which constitutes some elevated summits, among others that of

Hocherberg, near Waldmohr, and which divides the coal measures into two basins very different from each other."

"The southern coal basin, which sheds its waters into the Sarre, belongs to the best characterized and richest coal measures. The general direction of its beds is SW and NE. On the N and E it would appear that this formation rests upon the red sandstone that surrounds it, and whose beds appear in some places on the banks of the Blies, near Neunkirchen, to the SE of Ottweiler, to dip beneath the coal measures. These are principally composed of alternating beds of argillaceous schist, slaty clay, and schistose sandstone, in which are observed numerous impressions of ferns and other plants common to this formation; of micaceous sandstone, or coal measure sandstone; and of argillaceous and quartzose conglomerates. The formation contains good and numerous beds of coal worked in the environs of Sarrebruck, and also beds and abundant masses of earthy carbonate of iron ore, in the nodules of which are sometimes remarked impressions of fish, particularly in the upper part of the coal measures, as in the environs of Lebach. This formation also contains, but only between its upper strata, beds of compact limestone, grey or black, with a splintery fracture, and sometimes a schistose structure. On the SW the coal measures dip beneath the red sandstone, and are found by traversing the sandstone;" being overlaid, as it would appear, by the new red or saliferous sandstone.

"The northern or Glane coal basin, which principally comprises the banks of the Glane and its confluents, sheds its waters into the Nahe. No general direction can be observed in the stratification of its beds. The most southern coal beds, which are the best of the whole basin, incline to the N, and thus appear to rest on the band of red sandstone which separates them from the Sarre coal basin; but more on the N, the beds of coal worked often incline nearly parallel to the slope of the mountains that contain them, and the general disposition of the beds appears to be determined by the inequalities in the surface of an inferior rock situated at a slight depth. In this basin, beds of compact limestone, of a dark colour, occur very frequently in the midst of the schists and conglomerates, and even in many places appear (near Wolfstein, Rothseelberg, &c.) beneath the whole coal formation. They resemble those met with in the western part of the basin of the Sarre, placed there between the upper strata of the coal measures. But the principal mass of the Glane coal formation is often formed of argillaceous schists, with little or no impressions, and commonly alternating with schistose sandstone; but the variety of sandstone especially known by the name of the coal measure sandstone, is rather rare. A coal almost always dry and of bad quality often occurs in these rocks, forming in each mountain one, or at most two

small beds of a few inches thick, in general situated near the surface. The coal is nearly always immediately covered, and also sometimes divided into two beds, by a limestone of a dull-yellow or blackish-brown, or presenting different mixtures of these two colours; so that in numerous mines the coal and limestone are worked together. Bituminous schists have also been observed in this formation, sometimes presenting impressions of fish penetrated with sulphuret of mercury. On its north-eastern limit the coal formation is covered in the environs of Alzey by horizontal limestone, which extends on the N and E to the banks of the Rhine;" belonging, as it appears, to the formations posterior to the chalk.

The preceding description by M. de Bonnard shows distinctly that in the tract which forms the subject of his memoir, we have the old red sandstone supporting two coal basins; in the northern of which, or that of the Glane, the carboniferous limestone not only appears in many places forming the immediate base of the coal formation, but is also interstratified with the coal measures, then commonly serving as the immediate roof of the coal. In the southern, or the Sarre coal basin, on the other hand, the carboniferous limestone occurs only between the upper strata of the coal measures. Now, this extensive carboniferous series is distinguished on M. Omalius d'Halloy's map, and in his memoir as the todte liegende or ancient red sandstone group, including the coal measures, quite in conformity with the German sense of that term.* Indeed Mr. De la Beche himself cannot avoid admitting (see the note, p. 223), that the old red sandstone supports the coal measures of the Palatinate, thus invalidating his own position on the map and elsewhere, that the todte liegende, or rothe liegende, group denotes a new red sandstone conglomerate. I think it needless to point out the repeated instances of this misconstruction of the term in other parts of the work, since what has been said admits of general application. I will, therefore, merely add, that in thus applying the term *new* red sandstone conglomerate to the *ancient* red sandstone group of Werner (which includes the coal tracts), a violence is done to

* See the construction of Freiesleben and of other German authors on this subject in the *Annals of Philosophy* for Aug. 1822, and May, 1823.

See also the memoir of M. von Hoff in Mr. De la Beche's Selection, p. 92, where, after describing the primary and transition rocks of the Thuringerwald, he proceeds thus:—"Those conglomerates, and micaceous or quartzose red sandstones (*conglomerat, rothes und graves liegende*), which together compose the formation named red sandstone, considered the most ancient of the secondary (floetz) formations, are the most extensively spread of all the rocks in the Thuringerwald;" and p. 93, "The coal formation of the Thuringerwald appears to belong, as a subordinate member, to the preceding."

If we combine also the valuable description given by M. de Bonnard, of the primary and transition tracts of the Hartz (p. 262—273 of the Selection), with Freiesleben's account of the carboniferous series of the Hartz and the adjacent districts (as abstracted by me in the numbers of the *Annals of Philosophy* referred to above), the geological succession of the primary transition, and carboniferous series, will be found as obvious there as it is in M. von Hoff's description of the Thuringerwald.

nature; while in the construction of the term rothe todte liegende, a double error is committed; namely, a positive one, in applying it at all to the weissliegende (the calcareous, or new conglomerate, the lowest bed of the alpine or magnesian lime stone), an error sufficiently exposed by Freiesleben (vol. iii. p 239); and a negative one, in not applying it where alone it is strictly due; namely, to the red sandstone of the carboniferous series in general. It follows that the rothe todte liegende and porphyry of the Synoptical Table of Mr. De la Beche, are both superfluous and out of place, the todte liegende being, as already repeatedly observed, but an adjunctive designation of the red sandstone of the carboniferous series, and porphyry occurring both among the coal measures and in the old red sandstone.

It will be seen from the memoir of M. de Bonnard, that the carboniferous series of the Palatinate is also associated with trap rocks, maintaining in this respect likewise its analogy to the same series in other countries.

The porphyry of Mont Tonnerre, &c. upon which this carboniferous series reposes on its eastern confines, appears to be of primary origin, containing veins of tin and other metals. Near Alberschweiler the porphyry passes into granite.

French geologists have generally, until very lately, been in the habit of referring the carboniferous limestone and the old red sandstone to the transition series, and hence the former has been designated by them as transition limestone, and the latter as a greywacke. The memoir of M. de Bonnard, and the map and memoir of M. Omalius d'Halloy, are indicative of more correct views. That their former persuasion may have been mainly influenced by the declaration of M. von Humboldt, respecting the English carboniferous limestone and old red sandstone, appears very probable.* The opinion of this distinguished naturalist respecting the Derbyshire limestone appears to have been adopted at a very early period, before its relations had been well ascertained; and with respect to the old red sandstone of Herefordshire, considered by him as transition or greywacke, it has evidently been confounded with the real transition red sandstone of that county. Indeed M. von Humboldt expressly states (p. 107 and 159 of the Essai), that the transition red sandstone of May Hill, the transition limestone of Longhope, the old red sandstone of Mitchel Dean, and the mountain limestone above it, are but repetitions or alternations of the same sandstone and limestone, all belonging to the transition series. This is a view, however, that will not receive support from any British geologist; and that the two latter formations are essen-

* See the Traité de Géognosie of M. d'Aubuisson, vol. ii. § 256; and the Essai sur le Gisement des Roches dans les deux Hémisphères, of the Baron Alexander von Humboldt, *passim*.

tially distinct from the two former, will, I trust, be made sufficiently evident in a paper of mine, which will appear in the concluding part of the first volume (New Series) of the Geological Transactions, now in course of publication. That the opinion of M. von Humboldt is altogether founded in misconception, particularly of the language of Prof. Buckland, must, I think, clearly appear from the following extracts :—

"The old red sandstone of Herefordshire of Mr. Buckland, placed below the transition limestone (mountain limestone) of Derbyshire, is a transition sandstone, as has been very well indicated by this excellent geognost himself, in his Memoir on the Structure of the Alps" * (*Annals of Philosophy*, June, 1821); in which Prof. Buckland is made to say directly the reverse of what he intended to express; namely, that some foreign geologists (especially of the French school) had *erroneously* denominated as greywacke and transition limestone the old red sandstone and carboniferous limestone of the English, which, on the contrary, are but the leading members of a totally different series; namely, of the carboniferous, or, in other words, of the *grande formation de grès rouge*. Had M. von Humboldt himself had an opportunity of studying the relative position, characters, and freedom from fossil shells, of the old red sandstone of the British Isles, it is impossible that he could have avoided recognizing it as representing neither more nor less than the fundamental portion of the carboniferous tracts. His own language indeed may be adduced to prove this, being directly at issue with his former position : " the red sandstone formation (meaning the carboniferous series, see Dr. Bouè sur l'Ecosse, p. 376), which occupies the greater portion of Ireland, is common in the north of Germany, in the Black Forest, and in the Vosges."† Now these tracts all belong to precisely the same series as the corresponding tracts of Great Britain, and the old red sandstone of the one has just as much pretension to a transition character, or the name of greywacke, as the other. I may on this occasion advert to the extremely loose manner in which the term greywacke is employed by many German geologists, who are apt to include sandstone in this designation, when found in the transition period, and, as it appears (though unintentionally), when found out of it, e. g. in the old red sandstone. If we are to speak a language that shall always be intelligible, it becomes necessary that each term should retain its own peculiar signification. A

* P. 157 of the Essai. " Le *vieux grès rouge* (old red sandstone du Herefordshire) de M. Buckland, placé sous le calcaire de transition (mountain limestone) de Derbyshire, est un grès du terrain intermédiaire, comme cet excellent géognoste l'a très-bien indiqué lui-même dans son Memoire sur la Structure des Alpes."

† P. 212. " La formation de grès rouge qui constitue la majeure partie de l'Irlande, et qui est si commune dans l'Allemagne septentrionale, dans la Forêt-noire et dans les Vosges, manque (de même que la formation des porphyres) presque entièrement dans las hautes Alpes de la Suisse."

second misconception of the language of Prof. Buckland is no less remarkable.

"The *new red conglomerate* of Exeter is the red sandstone of French mineralogists, or *todte liegende* of German mineralogists; it is the first secondary (floetz) sandstone; that is to say, *the sandstone of the carboniferous tract*, which is intimately connected with secondary porphyry, and hence the latter is called the porphyry of the red sandstone."* But the position of Prof. Buckland is directly the contrary; namely, that the red conglomerate of Exeter does not at all belong to the carboniferous series, and is altogether of an origin posterior to it, and hence denominated *new*. With respect, however, to the real period, to which the red conglomerate in the vicinity of Exeter may more appropriately be referred, should its connexion there with the amygdaloidal trap be ascertained beyond dispute, I confess I should rather side with the opinion of M. von Humboldt; namely, that both belong to the carboniferous series. But should there be no such decided connexion, it may yet appear that the amygdaloid belongs to the transition tract of that country, and the conglomerate itself to the gypseous or new red sandstone, that is known to prevail in that part of the kingdom.

I have more than once found it necessary to show, that English geologists have misunderstood the true import of the older red sandstone group, or rothe todte liegende, of German authors; and additional evidence of this fact is to be found in the construction put upon these terms throughout the very interesting and important work of M. von Humboldt. See in particular the first division of the Terrains Secondaires, p. 205, et seq. from which, in addition to preceding extracts, I select only the following:—"It is difficult to assign a general type for the order of the different beds which constitute the great formation of coal, red sandstone, and porphyry (with interposed beds of amygdaloid, greenstone, and limestone). The coal appears most commonly below the red sandstone, and sometimes it is evidently placed either in this rock or in the porphyry."† This last sentence appears more particularly referable to certain parts of Germany, where only a portion of the carboniferous series is displayed, e. g. in Thuringia; but from such merely local facts no general inference can be drawn. "Sometimes the great deposit of coal is not covered by porphyry and red sandstone; sometimes it occupies great basins surrounded by hills of red

* P. 157. "Le *nouveau conglomérat rouge* (new red conglomerate d'Exeter) est le grès rouge des minéralogistes francois, ou *todte liegende* des minéralogistes Allemands; c'est le premier grès du terrain secondaire, c'est à dire le grès du terrain houiller, qui est intimement lié au porphyre secondaire, appelé pour cela porphyre du grès rouge." See also p. 205.

† P. 209. "Il est difficile d'assigner un type général à l'ordre des différentes assises qui constituent la grande formation, § 26. La houille paroit le plus souvent au-dessous du grès rouge; quelquefois elle est placée évidemment ou dans cette roche ou dans le porphyre."

sandstone and porphyry, and presents in its roof only alternating beds of slate-clay and carbonated shale, the former containing numerous impressions of ferns. Thin beds of coaly shale, beds of quartzy sandstone passing into granular quartz, of large-grained conglomerate (coal measure conglomerate), and of fetid limestone also, are met with in the midst of the slate-clay before the coal is attained."*

On the other hand, it is equally certain, that Continental geologists have misconceived, in some instances, the purport of the language employed by English writers. Hence has arisen a double confusion; when, after all, if the language of each had been correctly apprehended, there would have been as little discrepancy in description as there is in the appearances of nature, since the facts themselves are perfectly reconcileable to each other.

To attempt to clear away difficulties and dispel obscurity is both an irksome and ungrateful task; and the love of truth alone has impelled me to it. If it shall be found that I have in any degree succeeded in throwing a clearer light upon a complicated subject, my purpose will be fully answered. The researches of M. Constant Prevost, an eminent French geologist, and FMGS. who is at present engaged in examining the geological relations of this country with a critical eye, will, I have not a doubt, conduce to the same desirable end.

I have upon former occasions remarked, that all the established relations of the old red sandstone, carboniferous limestone, and coal formation, to each other, as founded upon the researches and descriptions of naturalists in different countries, prove that they constitute one group of the same era; yet varying much in the modes of their association, as being found in one tract distinct from, and in another more or less interstratified with each other. The following view, which may be of some value in reference to practical and economical purposes, will be found to embrace a summary of those relations.

1. Old red sandstone, carboniferous limestone, and the coal formation, in separate and distinct succession, not interstratified upon their several confines; e. g. the general case in Ireland. This may be considered as the distinct type of the series.

N. B. The bed of sandstone and conglomerate, found in some tracts interposed between the limestone and the coal measures,

* P. 207. "Souvent le grand depôt de houille n'est pas recouvert de porphyre et de grès rouge. Souvent il est placé dans les basins entourés de collines de grès rouge et de porphyre, et n'offre dans son toit que des couches alternantes d'argile schisteuse (schieferthon), tantôt gris-bleuâtre, tendres et remplies d'empreintes de fougères, tantôt compactes, carburées (brandschiefer) et pyriteuses. Des minces strates de grès charbonneux (kohlenschiefer), de grès quartzeux passant au quartz grenu, de conglomérat à gros fragmens (steinkohlen-conglomerat), et de calcaire fétide, se rencontrent au milieu du schieferthon avant qu'on atteigne la houille."

and designated in England as the *millstone-grit,* is wanting in Ireland.

N. B. This peculiar application of the term *millstone-grit* is bad as a distinction, since a similar compound is generally found in beds in the fundamental or old red sandstone, and in some countries also frequently interstratified with the coal measures, e. g. in Germany.

2. A base of old red sandstone, supporting limestone, which alternates with sandstone, a considerable bed of the latter, with conglomerate, forming the immediate foundation of the coal measures, which are distinct; e. g. the Gloucestershire south coal basin.

N. B. The more common coal bearing measures are in this basin separated into a lower and an upper series by an intervening thick bed of reddish sandstone, locally known by the name of *Pennant-stone.*

N. B. A similar occurrence, on a larger or smaller scale, is not uncommon in Germany, and when the red sandstone thus occurs immediately under the magnesian or alpine limestone (with its calcareous or new conglomerate, the *weissliegende*), it is known by the name of todte liegende, or rothe liegende, or rothe todte liegende, in the same manner as these terms are applied to the fundamental red sandstone when also directly covered by the calcareous conglomerate and magnesian limestone. But the term rothe todte liegende has also been often erroneously applied, as already noticed above, to the calcareous or new conglomerate itself.*

3. A base of old red sandstone, supporting and alternating with some beds of limestone, succeeded by a coal formation, composed, in an ascending order, as follows:

a. Of coal measures alternating with limestone, and with reddish sandstone, the coal being inconsiderable in quantity.

b. Productive coal measures, alternating with numerous beds of limestone.

* M. von Humboldt correctly distinguishes the weissliegende, as the bed which intervenes between the coal formation and the zechstein, or magnesian limestone (see p. 224 of the Essai). It thus corresponds with the calcareo-magnesian, or new conglomerate of England, appearing as its only representative.

On the other hand, however, both M. von Humboldt and Dr. Boué speak of the zechstein, or magnesian limestone, as occurring sometimes interstratified with the coal measures. This is a position utterly at variance with all experience in the British Isles, and seems quite untenable, if we consider that the calcareous conglomerate, or weissliegende, is commonly found in an unconformable position, overlying both the coal measures, and the carboniferous series in general; being the first member of a new series; namely, of the gypseo-saliferous. In the instance quoted, e. g. in Lower Silesia (p. 34, 213, &c.) it is true that, in the year 1802, M. von Buch considered the limestone in question as zechstein, and as such as of an origin posterior to, and placed above the coal formation; but M. von Raumer in 1819 clearly showed that this limestone was repeatedly interstratified with the coal measures, and therefore not zechstein; and certainly no two series can be generally more distinct from each other than the carboniferous and the gypseo-saliferous series. Other instances cited, probably rest upon no securer foundation than misconception, or fallacious description.

c. Coal measures, abundant in coal, but free from limestone.
E. g. in the Scotch great coal tract.

4. A base of old red sandstone, supporting limestone, which not only constitutes the foundation of the coal formation, but alternates with the coal measures, often forming the immediate roof of the coal seams: e. g. the Glane coal basin, described above.

5. A base of the same old red sandstone, supporting a coal formation, composed, in an ascending order:

a. Of productive coal measures alternating with beds of sandstone conglomerate.

b. Of coal measures alternating with limestone.

E. g. the Sarre coal basin, described above.

N. B. The coal measures of this basin are overlaid on the W and S by the new red or saliferous sandstone; so that if the series of coal measures be continued in that direction, and toward which they dip, they are withdrawn from observation. Could we follow them, it appears not improbable that the succeeding coal measures might be found free from limestone. But be this as it may, it is remarkable that in this coal field, the greatest number of the coal seams are found above the fundamental red sandstone, and beneath the limestone bearing strata, being thus directly connected with the former.

The carboniferous series of all countries, whose members are complete, will probably be found referable to one or other of the preceding modes of association. In addition to those which relate to the alternation of the carboniferous limestone with the coal measures, may be cited analogous appearances in Silesia and Hungary, as described by MM. von Raumer and Beudant. The New Continent also presents, it seems, similar relations; e. g. in the coal formation of the Ohio, in the great basin of the Mississippi, where coal seams are represented as occurring both above and beneath the limestone.*

The preceding examples refer to tracts where all the members of the series are present; but in some districts, the carboniferous limestone is found altogether wanting, the coal formation being directly connected with the old red sandstone; while in others, both the limestone and old red sandstone being absent, a simple coal formation is only met with. But in all cases, the series, whether complete or incomplete, reposes either on transition, or on primary tracts, or on both of these conjointly.

The occasional association of trappean, amygdaloidal, and porphyritic rocks, both separately with the individual members, and conjointly with the series in general, is now too well known to require more than the simple notice of the fact.

* See the Account of an Expedition from Pittsburg to the Rocky Mountains in 1819 and 1820, by Edwin James, Botanist and Geologist to the Expedition. London, 1823.

ART. IV.—*Corrections in Right Ascension of 37 Stars of the Greenwich Catalogue.* By James South, FRS.

Mean AR 1824.	γ Pegasi h. m. s. 0 4 11·17	Polaris h. m. s. 0 58 2·66	α Arietis h. m. s. 1 57 16·42	α Ceti h. m. s. 2 53 5·44	Aldebaran h. m. s. 4 25 50·01	Capella h. m. s. 5 3 42·21	Rigel h. m. s. 5 6 5·11	β Tauri h. m. s. 5 15 10·52	α Orionis h. m. s. 5 45 38·93
July 1	+ 2·79″	+ 3·27″	+ 2·33″	+ 1·92″	+ 1·76″	+ 2·00″	+ 1·24″	+ 1·81″	+ 1·47″
2	82	4·07	36	95	78	03	26	83	49
3	85	4·86	40	97	81	06	28	85	50
4	88	5·66	43	2·00	83	09	30	88	52
5	91	6·46	46	03	85	12	32	90	53
6	95	7·26	49	06	88	14	34	92	55
7	98	8·05	53	09	90	17	36	94	57
8	3·02	8·85	56	12	93	20	38	97	59
9	05	9·65	59	15	95	23	40	99	61
10	08	10·44	62	18	98	26	42	2·02	63
11	11	11·22	66	21	2·01	29	44	04	65
12	14	12·01	69	24	03	32	46	07	67
13	17	12·79	72	27	06	36	49	09	69
14	20	13·58	75	30	09	39	51	12	71
15	23	14·39	79	32	12	42	53	15	73
16	26	15·20	82	35	15	45	55	17	75
17	29	16·01	86	38	18	48	57	20	77
18	32	16·82	89	41	20	51	60	22	79
19	35	17·63	93	44	23	55	62	25	81
20	38	18·40	96	47	26	58	64	28	83
21	41	19·17	99	50	29	62	67	31	85
22	43	19·94	3·03	54	32	65	69	33	87
23	46	20·72	06	57	35	69	71	36	90
24	49	21·49	09	60	38	72	74	39	92
25	52	22·25	12	63	41	76	76	42	95
26	55	23·01	15	66	44	79	79	45	97
27	57	23·77	18	70	47	82	81	47	99
28	60	24·54	22	73	50	86	84	50	2·02
29	63	25·30	25	76	52	90	86	53	04
30	65	26·03	28	79	55	94	89	56	07
31	68	26·76	32	82	58	98	91	59	09
Aug. 1	70	27·48	35	85	61	3·01	94	62	11
2	73	28·21	38	88	64	05	97	65	14
3	75	28·94	41	91	67	09	99	68	16
4	78	29·66	45	94	70	13	2·02	71	19
5	80	30·39	48	97	73	16	05	74	21
6	83	31·11	51	3·00	76	20	08	77	24
7	85	31·84	54	03	79	24	10	80	26
8	88	32·56	58	06	82	28	13	84	29
9	90	33·23	61	09	85	32	16	87	32
10	92	33·90	64	12	88	36	19	90	35
11	95	34·57	67	15	91	40	21	94	37
12	97	35·25	70	18	94	44	24	97	40
13	99	35·92	73	21	97	49	27	3·00	43
14	4·01	36·58	76	24	3·01	53	30	03	46
15	03	37·24	79	27	04	57	33	06	49
16	05	37·90	82	30	07	61	35	09	51
17	08	38·56	85	33	10	66	38	13	54
18	10	39·21	88	35	13	70	41	16	57
19	12	39·81	91	38	16	74	44	19	60
20	14	40·41	94	41	19	78	47	23	62
21	16	41·00	96	43	22	82	49	26	65
22	18	41·60	99	46	25	86	52	29	68
23	20	42·20	4·02	49	28	90	55	32	71
24	22	42·77	05	52	31	95	58	35	74
25	23	43·34	08	55	34	99	61	38	76
26	25	43·90	11	58	37	4·03	63	42	79
27	27	44·47	13	61	40	07	66	45	81
28	29	45·04	16	63	43	11	69	49	84
29	30	45·54	18	66	46	15	72	52	87
30	32	46·05	21	68	49	20	75	56	90
31	33	46·55	23	71	53	24	78	59	93

	Sirius	Castor	Procyon	Pollux	α Hydræ	Regulus	β Leonis	ζ Virginis	Spica Virg.
Mean AR 1824.	h. m. s. 6 37 23·49	h. m. s. 7 23 21·46	h. m. s. 7 30 5·32	h. m. s. 7 34 32·18	h. m. s. 9 18 56·44	h. m. s. 9 58 59·57	h. m. s. 11 40 4·73	h. m. s. 11 41 31·86	h. m. s. 13 15 56·07
July 1	+ 0·89″	+ 1·78″	+ 1·41″	+ 1·74″	+ 1·51″	+ 1·93″	+ 2·35″	+ 2·37″	+ 2·91′
2	90	79	42	75	51	93	34	36	90
3	91	80	43	76	51	92	33	35	89
4	93	81	43	76	51	92	32	35	88
5	94	82	44	77	50	92	31	33	87
6	95	82	45	78	50	91	30	33	86
7	96	83	45	78	50	91	30	32	85
8	98	84	46	79	50	91	29	32	84
9	99	85	47	80	49	90	28	31	83
10	1·00	86	48	81	49	90	27	30	82
11	02	88	49	82	49	89	26	29	81
12	03	89	50	83	49	89	25	29	80
13	04	91	52	85	49	89	24	28	79
14	06	93	53	86	49	89	23	27	79
15	07	94	54	87	49	88	23	26	78
16	09	96	55	88	49	88	22	26	77
17	10	97	56	89	49	88	21	25	76
18	12	99	58	91	49	88	20	24	75
19	13	2·00	59	92	49	87	19	23	74
20	15	02	60	94	49	87	18	22	73
21	17	03	62	95	50	87	17	22	72
22	18	05	63	97	50	87	17	21	71
23	20	07	64	98	51	87	16	20	70
24	22	09	65	2·00	51	87	15	19	69
25	24	10	66	01	51	87	14	19	68
26	26	12	68	03	52	88	13	18	66
27	27	14	69	05	52	88	13	17	65
28	29	15	71	06	52	88	12	17	64
29	31	17	72	08	53	88	11	16	63
30	33	19	74	10	54	88	10	16	62
31	35	21	75	12	54	89	10	15	61
Aug. 1	37	23	77	14	55	89	09	15	60
2	39	25	79	15	56	89	09	14	59
3	41	27	81	17	57	89	08	14	58
4	43	29	82	19	57	89	07	13	57
5	45	31	84	21	58	90	06	13	56
6	47	33	86	23	59	90	05	12	55
7	50	35	87	25	59	90	05	12	53
8	52	38	89	27	60	91	04	11	52
9	54	40	91	29	61	91	04	11	51
10	56	43	93	31	62	92	03	10	50
11	58	45	95	34	63	92	03	10	49
12	61	47	97	36	64	93	03	10	48
13	63	50	99	38	64	93	02	10	47
14	65	53	2·02	40	65	94	02	09	46
15	67	55	04	42	66	94	02	09	45
16	70	57	06	45	67	95	01	09	44
17	72	60	08	47	68	95	01	08	43
18	74	62	10	49	69	96	00	08	42
19	76	65	12	51	70	97	00	07	41
20	78	67	14	54	71	98	00	06	40
21	81	70	16	56	73	99	00	05	39
22	83	72	18	58	74	2·00	00	05	38
23	85	75	20	61	75	01	00	04	37
24	87	77	22	63	76	02	00	03	37
25	89	80	24	65	78	03	00	02	36
26	91	83	26	68	79	04	00	01	35
27	94	85	28	70	80	05	00	1·98	34
28	96	88	31	73	81	06	00	97	33
29	99	91	33	76	82	07	00	98	32
30	2·02	95	36	78	84	08	00	99	32
31	05	98	38	81	85	10	00	2·01	31

Mean AR 1824.	Arcturus h. m. s. 14 7 38·33	2 α Libræ h. m. s. 14 41 9·63	α Cor.Bor. h. m. s. 15 27 14·45	Serpent. h. m. s. 15 35 36·47	Antares h. m. s. 16 18 27·91	αHerculis h. m. s. 17 6 37·72	αOphiuchi h. m. s. 17 26 46·24	α Lyræ h. m. s. 18 30 58·99	γ Aquilæ h. m. s. 19 37 53·68
July 1	+ 2·97″	+ 3·52″	+ 3·23″	+ 3·48″	+ 4·44″	+ 3·62″	+ 3·68″	+ 3·42″	+ 3·74″
2	96	51	22	47	44	62	68	42	75
3	95	50	21	47	44	62	68	43	76
4	94	50	21	46	43	62	68	43	78
5	93	49	20	46	43	62	69	44	79
6	92	48	19	45	43	62	69	44	80
7	91	47	18	45	43	62	69	45	81
8	89	47	18	44	43	62	70	45	83
9	88	46	17	44	42	62	70	46	84
10	87	45	16	43	42	62	70	46	85
11	86	44	15	42	41	61	70	46	86
12	84	43	14	42	41	61	70	46	87
13	83	42	12	41	40	61	70	46	88
14	82	41	11	40	40	61	69	46	89
15	81	40	10	39	39	60	69	46	90
16	80	39	09	38	39	60	69	45	91
17	79	38	08	37	38	60	69	45	92
18	77	38	06	37	38	59	68	45	93
19	76	37	05	36	37	59	68	45	94
20	75	36	04	35	36	58	68	45	95
21	73	35	02	34	35	57	67	44	95
22	72	34	01	33	35	57	67	44	96
23	71	33	2·99	32	34	56	66	43	96
24	69	32	98	31	33	55	66	43	97
25	68	31	96	30	32	54	65	42	97
26	66	30	95	29	32	54	65	42	98
27	65	29	93	28	31	53	64	41	99
28	63	28	92	27	30	52	64	41	99
29	62	26	90	25	29	51	63	40	4·00
30	61	25	89	24	28	50	62	39	00
31	59	24	87	23	27	49	61	38	00
Aug. 1	58	22	86	21	26	48	60	37	00
2	57	21	84	20	24	47	59	36	01
3	55	20	83	19	23	46	58	35	01
4	54	19	81	18	22	45	57	34	01
5	52	18	80	17	21	44	56	33	01
6	51	17	78	16	20	43	55	32	02
7	49	15	77	14	18	42	54	31	02
8	48	14	75	13	17	41	53	30	02
9	46	13	73	12	16	40	52	29	02
10	45	11	71	10	14	38	51	27	01
11	43	10	69	09	13	37	50	26	01
12	42	09	67	08	12	36	49	25	01
13	40	08	65	06	10	34	48	23	01
14	39	07	64	05	09	33	47	22	00
15	37	06	62	03	07	31	46	20	00
16	36	04	60	02	06	30	45	19	3·99
17	34	03	58	01	04	28	44	17	98
18	32	01	56	2·99	03	27	42	16	98
19	31	00	54	98	02	26	41	14	97
20	29	2·98	52	96	00	24	39	12	96
21	28	97	50	95	3·99	23	38	11	96
22	27	96	48	93	97	21	36	09	95
23	25	95	46	92	96	20	35	07	95
24	24	94	44	90	94	18	33	05	94
25	22	92	42	89	93	17	32	04	94
26	21	91	40	87	91	15	30	02	93
27	19	90	39	86	90	14	29	00	93
28	18	88	37	84	88	12	27	2·98	93
29	17	87	35	83	86	10	25	96	92
30	16	86	33	81	85	09	24	94	91
31	15	84	32	80	83	07	22	91	90

Mean AR 1824.	α Aquilæ h. m. s. 19 42 11·88	β Aquilæ h. m. s. 19 46 40·23	2 α Capric. h. m. s. 20 8 17·02	α Cygni h. m. s. 20 35 26·21	α Aquarii h. m. s. 21 56 44·67	Fomalhaut h. m. s. 22 47 54·34	α Pegasi h. m. s. 22 56 0·17	γ Androm. h. m. s. 23 59 18·67
July 1	+ 3·77″	+ 3·78″	+ 4·12″	+ 3·32″	+ 3·49″	+ 3·61″	+ 3·10″	+ 2·81″
2	78	80	14	34	51	64	13	84
3	80	81	16	36	54	67	16	88
4	81	83	17	38	56	71	19	91
5	82	84	19	40	59	74	22	95
6	84	86	20	42	61	77	24	98
7	85	87	22	44	64	80	27	3·02
8	86	89	24	46	66	84	30	05
9	88	90	26	48	69	87	33	09
10	89	91	27	49	71	90	36	12
11	90	92	29	51	73	94	38	15
12	91	93	30	52	75	97	41	18
13	92	94	31	53	78	4·00	44	21
14	93	95	33	55	80	03	47	24
15	95	97	34	56	82	07	50	28
16	96	98	36	58	84	10	52	31
17	97	99	37	59	87	13	55	34
18	98	4·00	39	61	89	16	57	37
19	99	01	40	62	91	20	60	40
20	4·00	02	41	63	93	22	62	43
21	00	03	42	64	95	24	64	46
22	01	03	43	65	96	26	66	49
23	02	04	44	66	98	28	69	52
24	03	05	45	67	4·00	30	71	55
25	03	06	46	67	02	32	73	58
26	04	07	47	68	04	34	75	60
27	05	07	48	69	05	36	78	63
28	05	08	49	70	07	37	80	66
29	06	09	50	71	09	39	82	69
30	06	09	50	71	10	41	84	72
31	06	09	51	72	12	43	86	74
Aug. 1	06	09	51	72	13	45	88	77
2	07	10	52	72	15	47	90	80
3	07	10	52	73	16	49	92	83
4	07	10	53	73	18	52	94	85
5	07	10	53	73	19	54	96	88
6	08	11	54	73	21	56	98	91
7	08	11	54	74	22	58	4·00	94
8	08	11	55	74	24	60	02	96
9	08	11	55	74	25	62	04	98
10	07	11	55	73	26	63	05	4·00
11	07	11	55	73	28	65	07	03
12	07	10	55	73	29	67	09	05
13	07	10	55	73	30	69	11	07
14	06	10	56	72	31	70	13	09
15	06	10	56	72	32	72	15	12
16	06	09	56	72	33	74	16	14
17	05	09	56	71	34	75	18	16
18	05	09	56	71	35	77	19	18
19	04	08	56	70	36	78	20	20
20	04	08	55	70	36	79	21	22
21	03	07	55	69	37	81	22	24
22	03	07	55	68	37	82	23	26
23	02	06	54	67	38	83	24	28
24	02	05	54	67	39	84	26	30
25	01	05	53	66	39	85	27	32
26	00	04	53	65	40	87	28	34
27	3·99	04	52	65	40	88	29	36
28	99	03	52	64	41	89	30	38
29	98	02	51	63	41	90	31	40
30	97	01	51	62	41	90	32	41
31	96	00	50	60	42	91	32	43

	γ Pegasi	Polaris	α Arietis	α Ceti	Aldebaran	Capella	Rigel	β Tauri	α Orionis
Mean AR 1824.	h. m. s. 0 4 11·17	h. m. s. 0 58 2·66	h. m. s. 1 57 16·42	h. m. s. 2 53 5·44	h. m. s. 4 25 50·01	h. m. s. 5 3 42·21	h. m. s. 5 6 5·11	h. m. s. 5 15 10·52	h. m. s. 5 45 38·93
Sept. 1	+ 4·35″	+ 47·06″	+ 4·26″	+ 3·73″	+ 3·56″	+ 4·29″	+ 2·80″	+ 3·63″	+ 2·95″
2	36	47·56	29	76	59	33	83	67	98
3	38	48·03	31	79	62	38	86	70	3·01
4	39	48·50	34	82	65	42	89	74	04
5	40	48·96	36	85	69	46	92	77	07
6	42	49·43	39	88	72	51	95	81	10
7	43	49·90	41	90	75	55	98	84	13
8	44	50·30	43	92	78	59	3·01	87	16
9	45	50·70	46	94	81	63	04	91	19
10	46	51·10	48	96	84	67	06	94	22
11	47	51·50	50	98	87	70	09	97	25
12	48	51·91	52	4·00	90	74	12	4·01	28
13	49	52·26	55	02	93	78	15	04	30
14	50	52·61	57	04	96	82	18	08	33
15	51	52·96	59	06	99	85	20	11	36
16	52	53·32	62	09	4·02	89	23	15	39
17	53	53·67	64	11	05	93	26	18	42
18	54	53·96	66	14	08	98	29	21	45
19	55	54·25	68	16	11	5·02	32	25	48
20	56	54·53	70	19	14	07	34	28	51
21	56	54·82	72	21	17	11	37	31	54
22	57	55·11	74	24	20	16	40	34	57
23	58	55·35	77	26	23	20	43	38	60
24	59	55·59	79	29	26	25	46	41	63
25	60	55·83	81	31	28	29	48	44	66
26	60	56·08	83	34	31	34	51	48	69
27	61	56·32	85	36	34	38	54	51	72
28	61	56·49	86	38	37	42	57	54	75
29	62	56·66	88	40	39	46	59	57	78
30	62	56·82	89	42	42	50	62	60	81

	Sirius	Castor	Procyon	Pollux	α Hydræ	Regulus	β Leonis	β Virginis	SpicaVirg.
Mean AR 1824.	h. m. s. 6 37 23·49	h. m. s. 7 23 21·46	h. m. s. 7 30 5·32	h. m. s. 7 34 32·18	h. m. s. 9 18 56·44	h. m. s. 9 58 59·57	h. m. s. 11 40 4·73	h. m. s. 11 41 31·86	h. m. s. 13 15 56·07
Sept. 1	+ 2·07″	+ 3·01″	+ 2·41″	+ 2·84″	+ 1·87″	+ 2·11″	+ 2·00″	+ 2·02″	+ 2·31
2	10	04	43	87	88	12	00	03	30
3	13	07	46	89	90	13	00	04	30
4	16	10	48	92	91	14	00	06	29
5	19	13	51	95	93	15	00	07	28
6	22	16	53	97	94	16	00	08	28
7	25	18	55	·300	96	18	00	09	27
8	28	21	58	03	98	19	01	09	26
9	30	24	60	06	99	21	01	10	26
10	33	27	63	09	2·01	22	02	10	25
11	36	30	65	12	03	24	02	11	25
12	39	33	68	15	05	25	03	11	24
13	42	36	70	18	06	27	03	11	24
14	44	39	73	21	08	28	04	12	23
15	47	42	76	24	10	30	04	12	23
16	50	46	78	27	11	31	05	13	22
17	52	49	81	30	13	33	05	13	22
18	55	52	84	33	15	35	06	14	22
19	58	56	86	36	17	37	06	15	22
20	61	59	89	39	20	38	07	15	22
21	64	62	92	42	22	40	07	16	22
22	67	65	95	45	24	42	08	17	22
23	70	69	97	48	26	44	09	18	22
24	73	72	3·00	52	28	45	10	19	22
25	75	75	02	55	30	47	10	19	21
26	78	78	05	58	33	49	11	20	21
27	81	82	08	61	35	51	12	21	21
28	84	85	11	64	37	53	13	22	21
29	87	89	14	67	40	55	14	23	21
30	90	92	16	71	42	57	15	24	21

Mean AR 1824.	Arcturus h. m. s. 14 7 38·33	2 α Libræ h. m. s. 14 41 9·63	α Cor.Bor. h. m. s. 15 27 14·45	α Serpent. h. m. s. 15 35 36·47	Antares h. m. s. 16 18 27·91	αHerculis h. m. s. 17 6 37·72	αOphiuchi h. m. s. 17 26 46·24	α Lyræ h. m. s. 18 30 58·99	γ Aquilæ h. m. s. 19 37 53·68
Sept. 1	+ 2·13″	+ 2·83″	+ 2·30″	+ 2·78″	+ 3·82″	+ 3·05″	+ 3·21″	+ 2·89″	+ 3·88″
2	12	82	28	77	80	03	19	87	87
3	11	81	26	75	79	02	18	85	86
4	10	80	24	74	77	00	16	83	85
5	08	78	23	72	75	2·98	14	81	84
6	07	77	21	71	74	97	13	78	82
7	06	76	19	69	72	95	11	76	81
8	05	75	17	68	70	93	09	74	80
9	04	74	15	66	69	91	07	71	78
10	03	73	14	65	67	90	06	69	77
11	02	72	12	63	66	88	04	67	76
12	01	71	10	62	64	86	02	65	75
13	1·99	69	08	60	63	84	00	63	73
14	98	68	06	59	61	82	2·98	60	72
15	97	67	05	57	59	81	97	58	71
16	96	66	03	56	58	79	95	55	70
17	95	65	01	54	56	77	93	53	68
18	94	64	1·99	53	54	75	91	51	67
19	93	63	98	52	53	74	89	48	65
20	93	63	96	50	51	72	88	46	64
21	92	62	95	49	50	70	86	44	62
22	91	61	93	48	48	68	84	41	61
23	90	60	91	47	47	67	82	39	59
24	89	59	90	46	45	65	81	36	58
25	89	59	88	44	44	63	79	34	56
26	88	58	87	43	42	62	77	31	55
27	87	57	85	42	40	60	75	29	53
28	87	56	84	41	39	58	73	27	51
29	86	56	82	40	37	57	72	24	50
30	86	55	81	39	36	55	70	22	48

Mean AR 1824.	α Aquilæ h. m. s. 19 42 11·88	β Aquilæ h. m. s. 19 46 40·23	2 αCapricor h. m. s. 20 8 17·02	α Cygni h. m. s. 20 35 26·21	α Aquarii h. m. s. 21 56 44·67	Fomalhaut h. m. s. 22 47 54·34	α Pegasi h. m. s. 22 56 0·17	αAndrom. h. m. s. 23 59 18·67
Sept. 1	+ 3·95″	+ 3·99″	+ 4·49″	+ 3·59″	+ 4·42″	+ 4·91″	+ 4·33″	+ 4·44″
2	94	98	48	58	42	92	34	46
3	93	97	48	57	42	93	35	47
4	92	96	47	56	42	94	36	49
5	91	96	46	55	43	94	37	51
6	90	95	46	53	43	95	37	53
7	89	94	45	52	43	96	38	54
8	88	93	44	50	43	96	38	55
9	86	91	43	49	43	97	39	56
10	85	90	42	47	42	97	39	57
11	84	89	41	45	42	97	39	58
12	83	88	40	43	42	98	40	59
13	81	86	39	42	42	98	40	60
14	80	85	38	40	42	98	40	61
15	79	84	37	38	41	98	40	62
16	77	82	36	37	41	99	41	63
17	76	81	35	35	41	99	41	64
18	75	80	34	33	40	99	41	65
19	73	78	33	31	40	99	41	65
20	72	77	31	29	39	98	41	66
21	71	76	30	27	39	98	41	67
22	69	74	29	25	38	98	41	68
23	68	73	28	23	38	98	41	68
24	66	71	27	21	37	98	41	69
25	65	70	25	19	36	97	41	70
26	63	68	24	17	36	97	41	70
27	62	67	23	15	35	97	41	71
28	60	65	21	13	34	97	41	71
29	59	64	20	10	33	96	40	71
30	57	62	18	08	33	96	40	72

Article V.

*New Investigation of the Chemical Composition of Red Silver Ore.** By P. A. v. Bonsdorff.

In consequence of the analysis of red silver ore by Klaproth and Vauquelin, this mineral has been considered as a compound of sulphuret of silver, sulphuret of antimony, and oxide of antimony. Klaproth's last analysis of this mineral from Andreasberg (Beitrage, v. 197) makes its constituents as follows:

Silver	60
Antimony	19
Sulphur	17
Oxygen	4
	100

But both in this analysis, and in the others made upon the same mineral, although the quantities of constituents obtained were unequal, no positive proof was obtained of the presence of oxygen, or of oxide of antimony. It was merely concluded that the great loss sustained during the analysis was owing to the presence of oxygen. In this way Vauquelin reckoned the whole loss, which was about 12 per cent. as oxygen. And Klaproth, for the same reason, reckoned 4 or 5 per cent. of oxygen in his different analyses. But as the result of these analyses do not agree with any atomic proportions; and as both the existence and amount of the oxygen still depend upon imperfect and uncertain evidence, I was in hopes that a new analysis might not be destitute of all interest. In Prof. Berzelius's laboratory, I lately enjoyed a fortunate opportunity of undertaking the analysis of the dark red silver ore from Andreasberg; and I propose in this paper to give an account of the analytical experiments which I undertook, and of the result of them.

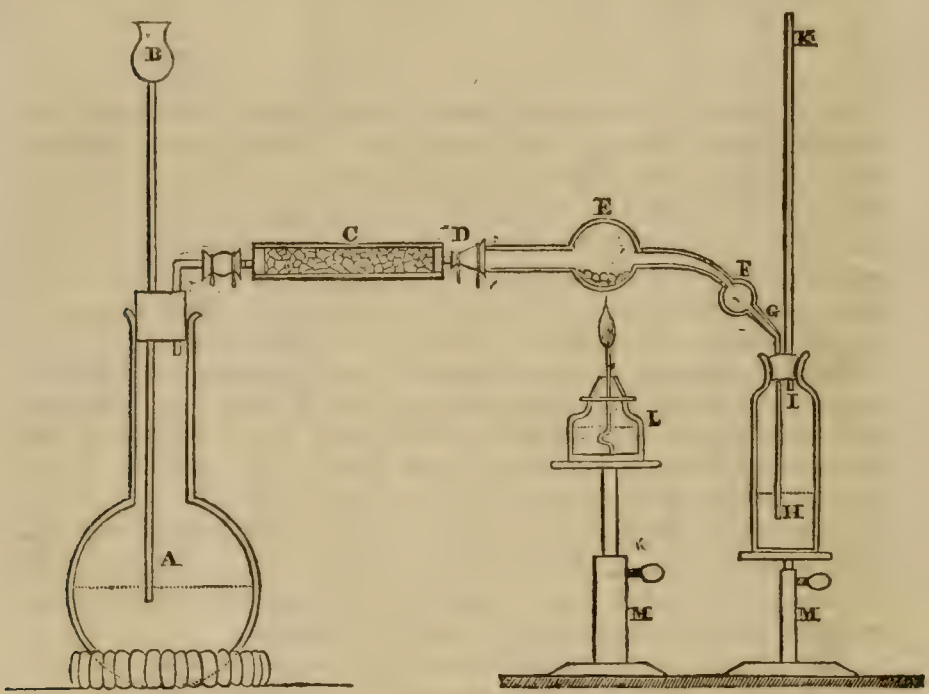
The first attempt was to extract the supposed oxide of antimony from the mineral by means of dilute muriatic acid. Picked specimens of the ore were reduced to the finest possible powder,† and digested with muriatic acid, rendered so weak as not to be able to decompose sulphuret of antimony. This degree of dilution was determined by means of a paper dipped in acetate of lead; but it was found that the acid when thus diluted would dissolve nothing whatever from the mineral.

* Translated from the Kongl. Vetenskaps Academiens Handlingar for 1821, p. 338.

† The pulverisation of this mineral is attended with considerable difficulty, because the parts of it become at last scaly, after which it is far from easy to reduce them to a finer powder, even under water.

The next attempt was to expose the mineral to the action of hydrogen gas, while at the same time heat was applied to it, in hopes that the hydrogen would reduce the oxide of antimony to the metallic state and form water, by the weight of which the quantity of oxygen in the mineral could be determined. But in order to satisfy myself in the first place that this theoretic speculation would accord with the nature of the bodies present, I undertook a set of experiments on the reduction of an artificial mixture of sulphuret and oxide of antimony by means of hydrogen gas.

The apparatus which was employed in these processes was constructed on almost the same idea as that described by Prof. Berzelius in his experiments on nickel glanse, arsenical nickel, &c.; an outline of which is here given.



It consisted of a globular vessel, A, in which the gas was generated, a tube, C, filled with chloride of calcium, and a small apparatus for distilling. But this last apparatus, distinguished in the figure by the letters D E F G H, was, in my experiments, not terminated by the ball, F, and the crooked tube, G H; but had on that side merely a straight tube rather more than two inches long, which was fastened to the ball, E, by a caoutchouc tube in the same way as the apparatus, D E, only somewhat greater. This tube was filled with chloride of calcium in the same way as the tube C, and from A there passed a crooked tube to allow the gas evolved to make its escape. The gas was

generated by dissolving granulated zinc in dilute sulphuric acid. All the different pieces of the apparatus were carefully weighed in the first place to enable me to determine what might be driven off, or what addition might be made to the substances operated on during the process.

Experiments with a Mixture of Sulphuret of Antimony and Oxide of Antimony.

Antimonious acid prepared from subantimonite of potash (*crocus antimonii elota*) by digestion in nitric acid, was mixed by trituration with its own weight of metallic antimony in fine powder, and put into a glass globular vessel blown by the lamp, having a capacity of fully a cubic inch, the mouth of which was afterwards drawn out into a capillary tube. This glass vessel was put into a crucible, and was raised to a red heat, which was kept up about ten minutes. When the glass was broken in pieces, there was found in its upper part white or yellowish-white crystals, of two different forms; namely, octahedrons and prismatic needles. The mass found at the bottom consisted of a metalline regulus lying undermost, and over it an oxide consisting of a fused yellow-grey mass, having a crystallized fracture, and containing drusy cavities, lined with white, short, needle-shaped crystals. Sulphuret of antimony was prepared from this regulus by mixing it with 40 per cent. of pure native sulphur, and heating it in a little glass globular vessel. It was crystallized, and all excess of sulphur had been driven off by heat.

The purest portions of the oxide thus obtained were pulverised, and exactly mixed with the sulphuret of antimony, according to the proportions which Berzelius has given for the constitution of red ore of antimony (*Rothspeissglanserz*), $Sb + 2\,SbS^3$; namely, 100 parts sulphuret with 43·2 parts of oxide. A quantity of this mixture was put into a glass globe blown by the lamp. This quantity after being gently heated weighed 2·335 grammes. The glass was exposed to the flame of a spirit-lamp, and as soon as the mixture became fully red-hot, it melted, and was found after cooling still to weigh exactly 2·335 grammes. The product of this operation was a glass having the metallic lustre and a dark steel-grey colour with a shade of red, very similar to the dark variety of red ore of antimony. It appeared opaque, except those portions which had formed a thin crust on the inside of the glass. These were translucent, and had a yellowish-red colour. When reduced to powder, it had a dark reddish-brown colour. As the weight was not altered by the fusion, it is obvious that it had lost no sulphur nor oxygen during the process.

A portion of the powder of this *crocus*, or compound of sulphuret and oxide of antimony, was put into the part of the apparatus marked E, which, after being gently heated, weighed

1·27 gramme. The caoutchouc tube was now fixed on, and all the other parts of the apparatus were adjusted to their places. After the hydrogen gas had passed over a good while, and the whole atmospherical air had been driven out of the tube, the powder was gradually heated by means of a spirit-lamp. Water began very quickly to be formed, and was deposited in the form of vapour on the sides of the glass globe. When the hydrogen gas passed over briskly, the aqueous vapour was carried off by the current, and was naturally absorbed by the chloride of calcium in G; but when the hydrogen gas passed over slowly, or only at intervals, the water collected in drops in the pipe. After the process had continued two or three hours, the antimoniacal mass had in part passed through the glass globe, and a little sulphur began to appear on its outside. The fire was of necessity withdrawn, and the process stopped. During the whole continuance of the operation sulphuretted hydrogen gas was disengaged, and conducted by means of the crooked tube into a glass containing liquid ammonia in order to prevent it from making its way into the room. Into the tube beyond the glass globe, 0·04 gramme of water had condensed, and the tube containing the chloride of calcium had increased considerably in weight. But it is needless to state this increase, because the portion of the chloride nearest the ammoniacal water had deliquesced in consequence of the evaporation of a portion of that liquid into it. The residual matter in E weighed 1·005; and consequently it had lost in oxygen and sulphur 0·265 gr. It consisted of a multitude of small metallic reguli, and of a brass-yellow crystallized sublimate, which seemed to have the octahedral form. There was also a little sublimate in the tube, which had more of the metallic lustre, and was more shining, and which probably was merely sulphuret of antimony. The yellow crystallized substance dissolved with ease in aqua regia, and seemed to consist chiefly of sulphur.

Decomposition of Red Silver Ore by Hydrogen Gas.

When it was thus ascertained that hydrogen gas is capable of reducing oxide of antimony from its combination with sulphuret of antimony, the same process was undertaken with *red silver ore*, and at the same time measures were taken to collect and decompose all the sulphuretted hydrogen formed during the process, that the quantity of sulphur in the ore might be likewise determined. For this purpose a somewhat concentrated solution of sulphate of copper was prepared, and a portion of it (previously deprived of its atmospherical air by boiling) was put into two phials; and another portion supersaturated with ammonia, so that a clear solution was obtained, was put into two other phials. A new portion of chloride of calcium was put into the tube G, and its weight was again determined, and from

it there was a communication by means of glass tubes with the phials holding the solution of sulphate of copper. These again communicated with the ammoniacal solution of copper in the other two phials, by means of glass tubes passing through corks in the mouths of the phials, precisely as in a common set of Woulfe's bottles. Into the glass globe E, a quantity of pulverised red silver ore was put, which, after having been gently heated, weighed 1·504 gramme. Then the whole apparatus was put in its place.

When the evolution of the gas had continued for half an hour, and the atmospherical air had been expelled, a spirit-lamp was applied to the ball E, and a stream of gas was made to pass equably and slowly. On the first application of the heat, a light coloured smoke appeared, and passed over into the pipe from E, but it vanished immediately, and left no trace behind it. Sulphuretted hydrogen gas was immediately formed, and instantly rendered the first phial turbid. Soon after a deposit began to appear in the second, then in the third, and at last even some deposit appeared in the fourth phial. In the ball and tube not the least trace of water made its appearance, and indeed nothing whatever but an exceedingly small quantity of smoke-like matter. After the heat had been continued without interruption for eight hours, the mineral had assumed the form of a metallic regulus, which easily melted by the heat of the spirit-lamp. And in the throat, and tube of the little apparatus E, an inconsiderable quantity of a greyish matter with the metallic lustre had sublimed. When the hydrogen gas ceased to be sulphureous, and the mineral to diminish any more, the gas was still allowed to pass for some time. The lamp was then put out, and the apparatus taken to pieces. The residue in the retort was found to weigh 1·2365 gr. The glass ball was broken, and the regulus taken out; it weighed 1·2255 gr. It had externally the metallic lustre; but was here and there covered with a little black powder; but its quantity was so small that it could not be separated. Probably it was nothing else than small reguli in very fine mechanical division. The tube beyond the glass ball, though it contained the smoke-like matter, was not sensibly increased in weight. The chloride of calcium had become heavier by 0·010 gr. and it was observed that the particles of salt were a little soiled by a fine brownish-grey matter. The hydrogen had taken from the mineral 1·504 − 1·2365 = 0·2675 gramme, which amounts to 17·785 per cent.

A set of experiments was now undertaken on the regulus, which exhibited all the characters of an alloy of silver and antimony. The object in view was to remove the antimony by cupellation, and leave the silver. But in the first place a set of experiments was made upon an artificial mixture of silver and antimony.

Experiments to separate Antimony from Silver by Cupellation.

Of this alloy, which was so formed as to contain about 31 per cent. of antimony, and which in its fracture and aspect perfectly resembled the regulus obtained from red silver ore, 0·738 gr. was placed in a bone-earth cupel, which was introduced into a red-hot muffle in a cupellating furnace. The heat in the muffle was increased by means of an air tube introduced into the muffle through a piece of charcoal placed in its mouth. The antimony was speedily driven off, and in great quantity; and when on increasing the heat, and blowing on the cupel with a bellows, no more antimonial fumes appeared, the silver regulus was withdrawn, and found to weigh 0·512 gr. It was ductile, and on the surface dull and greyish, showing that it was not quite free from antimony. It was, therefore, enveloped in five times its weight of pure lead, and exposed to the usual cupellating process till it assumed the appearance of pure silver. The regulus now obtained was silver-white, had a strong metallic lustre, and weighed 0·507 gr. It amounted, therefore, to 68 per cent. of the antimonial alloy; and the regulus first obtained contained about 1 per cent. of antimony. An experiment was made with another portion of the same alloy. It gave, after the first process, a dull regulus, whose weight was very nearly in the same proportion as in the experiment already described; and when it was dissolved in nitric acid, it left behind it a little oxide of antimony. The pure regulus obtained in the first experiment dissolved in that acid without leaving any residue whatever.

After these preliminary trials, 0·511 gr. of the regulus obtained from red silver ore was taken and treated in precisely the same way. The first process gave a regulus weighing 0·375 gr. dull, and with a yellowish-grey colour on the surface; and when it was cupellated with five times its weight of lead, it became silver-white and splendid, and weighed 0·370 gramme. It dissolved in nitric acid without any residue whatever, and gave with muriatic acid horn silver, weighing after fusion 0·490 gramme, equivalent to 0·369 silver, and thus corresponding very nearly with the original weight of the regulus. According to this experiment, the whole regulus, weighing 1·2255 gramme, contained 0·8866 gramme silver, and the antimony driven off weighed 0·3389 gramme.

The matter which had passed into the tube E weighed, as has been already mentioned, 0·011 gramme. The fragments of the glass to which that grey metallic-looking substance adhered, were digested in nitric acid, which dissolved a little sulphur, as was evident from the action of muriate of barytes on the liquid. What remained was dissolved in muriatic acid, and contained, as far as so small a quantity of matter could be tested, nothing

else than antimony. The sublimate, therefore, consisted of sulphuret of antimony. Its weight (determined by weighing the glass fragments before and after the digestion in the acids) was 0·0065 gramme. It consisted of course of 0·0047 antimony and 0·0018 sulphur. When we subtract this 0·0065 from the 0·011 (the total weight), there remain 0·0045, which consisted of a brown-coloured earthy matter, but too small in quantity to be submitted to any tests to determine its nature.

The sulphuret of copper which had precipitated in the different phials was collected on a filter, and well washed with water. It was then dissolved in aqua regia, which, after long digestion, left a light-yellow powder, consisting of sulphur. It weighed, when well dried, 0·106 gramme, and burnt easily, leaving a black-greyish residual matter, weighing scarcely a milligramme. The solution in aqua regia was precipitated warm by muriate of barytes. The sulphate of barytes obtained weighed 1·04 gramme, equivalent to 0·143 gramme sulphur. Thus the whole quantity of sulphur amounted to 0·248 gramme. The matter deposited on the chloride of calcium might also contain a little sulphur, left on it by the warm sulphuretted hydrogen gas; but it is impossible to determine its amount with accuracy.

The preceding analysis of red silver ore gives us the following constituents:

Silver	0·8866	or 58·949
Antimony	0·3436	22·846
Sulphur	0·2498	16·609
Earthy matter	0·0045	0·289
Loss	0·0195	1·307
	1·5040	100·000

If we examine this mineral in a theoretic point of view, we find that 58·949 silver combine with 8·76 sulphur; and that 22·846 of antimony unite with 8·549 sulphur. We see further that the sulphuret of silver is a compound of 1 atom silver and 2 atoms sulphur; while the sulphuret of antimony consists of 3 atoms sulphur and 1 atom antimony. The chemical formula for red silver ore, therefore, must be, $3\,Ag\,S^2 + 2\,Sb\,S^3$, which gives us its constituents as follows:

Silver	58·98
Antimony	22·47
Sulphur	17·55
	99·00

Appendix.

To explain the composition of red silver ore to the English readers, it will be merely necessary to substitute the atomic

weights of silver, antimony, and sulphur, as determined by Dr. Thomson, for the more complex numbers employed by Bonsdorf in the preceding calculations.

The atom of silver weighs	13·75
antimony	5·5
sulphur.	2·0

Red silver ore is a compound of 1 integrant particle of sulphuret of silver and 1 integrant particle of sulphuret of antimony. Sulphuret of silver is composed of

1 atom silver.	13·75
1 atom sulphur.	2·0
	15·75

Sulphuret of antimony of

1 atom antimony	5·5
1 atom sulphur.	2·0
	7·5

Hence the constituents of red silver are:

1 atom silver.	13·75 or	59·14
1 atom antimony	5·50	23·65
2 atoms sulphur.	4·00	17·21
	23·25	100·00

The numbers in the last column are exceedingly near the result obtained by Bonsdorf. Indeed, if the loss in his analysis was sulphuret of antimony, as is exceedingly likely, the theoretic numbers almost coincide with those derived from the analytical experiments.

ARTICLE VI.

On the Characters of some Mineral Substances before the Blowpipe. By J. G. Children, FRS. &c.

THE blowpipe, when skilfully handled, is the most convenient chemical instrument for mineralogical researches on a small scale that has hitherto been invented. By its means we are enabled in a few minutes to determine the principal ingredients in any mineral submitted to our examination, even though it be composed of several elements. By merely directing the flame of a small lamp on a fragment about half the size of a peppercorn, supported on a piece of charcoal, or in the platina forceps, most of the volatile substances, as sulphur, arsenic, zinc, cadmium, antimony, bismuth, and tellurium, may be detected;

baryta will be known by the greenish-yellow, and strontita by the crimson colour it imparts to the flame. By employing only three fluxes, carbonate of soda, borax, and the triple phosphate of soda and ammonia (salt of phosphorus), with the occasional use of the nitrate of cobalt, we can readily ascertain the presence of silica, alumina, magnesia, and almost all the fixed metallic oxides; and by the further examination of the fused globule, especially that with carbonate of soda, by dissolving it in a drop of muriatic or nitric acid, on a slip of glass, and applying the proper tests, unequivocal evidence may be obtained of the presence of any of the other earths or oxides of which the substance is composed, and even a tolerable estimate may frequently be formed of their respective proportions. By substituting nitrate of baryta as the flux, and using a slip of platina foil for the support, instead of the wire, the presence of either of the alkalies may, by the usual well-known processes, be detected, with equal ease and certainty, on the same minute scale of operation.

An advantage peculiar to this microscopic chemistry is the very small quantity of matter that is sufficient for examination, which may generally be detached from rare and costly specimens without injury, whereas for operations on a larger scale, it is necessary wholly or in great measure to destroy them. When the exact proportions of the ingredients of a mineral are required, recourse must necessarily be had to more elaborate processes, but even then previous examination by the blowpipe is of essential service, since by indicating the different substances present, it enables us to determine the most advantageous method to be adopted in the subsequent analysis. Convinced of the utility of this sort of investigation, I propose, from time to time, to publish in the *Annals* the blowpipe characters of such minerals as have not already been so examined. For those which form the subject of the present communication, I am indebted to the kindness of Mr. Brooke.

1. *Arfwedsonite.* (Phillips's Mineralogy, p. 377.)

Alone in the glass matrass, gives off a very little moisture at a red heat: no decrepitation; appearance of the assay scarcely at all altered.

Alone in platina forceps, swells up, and fuses with great ease into a brilliant, opaque, black globule.

With soda, on platina wire, in the oxidating flame, fuses readily into a dark-brown opaque globule, while hot; olive-green, cold. By the addition of nitre the green colour becomes much brighter. In the reducing flame the colour changes to a dark, slightly greenish-brown.

With borax, dissolves readily, and gives a transparent globule of a garnet-red colour, hot, which changes to a deep wine-yellow

on cooling. In the reducing flame, the colour is a deep bottle-green.

With salt of phosphorus, the action is very slow and imperfect; the globule is transparent, and, while hot, has a deep wine-yellow colour; when cold, it is colourless. In the reducing flame the colour is lighter, and more inclined to green, while hot; when cold, colourless. A considerable portion of the assay remains undissolved, in the form of a dark-grey silica skeleton.

2. *Latrobite.* (Phillips's Mineralogy, p. 380.)

Alone in the glass matrass, at a red heat, gives off pure water; no decrepitation.

Alone in forceps, fuses easily into a white enamel.

With soda, fuses into a semi-transparent, irregular globule, of a light azure colour, when cold. The colour of the globule is not uniform, spots of a deeper colour than the rest appearing scattered over the surface. By the addition of nitre, the blue colour is at first much exalted, and assumes a very slight greenish hue; but by long continued flaming, the blue colour disappears, and is succeeded by a peach-blossom red colour, very similar to that of the mineral. In the *reducing flame,* the colour is wholly destroyed.

With borax, dissolves very slowly, into a perfectly transparent, very light amethyst-coloured globule. In the *reducing flame,* the colour entirely disappears.

With salt of phosphorus, action slow, and solution imperfect; globule transparent, very light-yellow, hot; colourless and slightly opaline, cold. In the *reducing flame,* the globule is colourless and transparent, both hot and cold. An undissolved silica skeleton remains in the globule.

With nitrate of cobalt, the assay gives a fine blue colour, intensely deep on the fused edges.

By dissolving the soda globule in muriatic acid, &c. I obtained silica, alumina, lime, iron, and manganese.

The latrobite is accompanied by a dark-coloured, nearly black substance, dispersed through it, here and there, in minute specks, which have an uneven, shining fracture, but are too small to allow me to distinguish any thing more of their external characters.

With salt of phosphorus, they presented before the oxidating flame the phenomena detailed above, but in the *reducing flame,* they gave a transparent glass, colourless while hot, and of a fine, rather deep-amethyst colour when cold. This colour flies instantly on the globule being heated, and on its cooling to a certain point, returns as instantaneously. These dark specks, therefore, appear to be an ore of titanium.

I examined the mica, which is another concomitant of latro-

bite, thinking it possible that it also might contain titanium; but it gave no indication of that metal, either when fused in the reducing flame, with salt of phosphorus alone, or with the addition of a small morsel of tin-foil.

3. *The Matrix, or greyish-coloured substance, in which the latrobite is imbedded.*

Alone in the matrass, behaves like latrobite; appearance unaltered.

In forceps, bubbles up, and fuses into an irregular greyish globule.

With soda, in proper proportion to the assay, fuses into a greenish-grey, semi-transparent globule, which in the reducing flame is colourless. On platina foil, with soda and nitre, very slight indication of manganese.

With borax, dissolves very slowly; globule transparent, and deep-yellow, hot; colourless, cold; in the reducing flame nearly the same, but colour lighter, and more inclining to green.

With salt of phosphorus, nearly as with borax, except that the action is still slower, the yellow colour, in either flame, lighter, and without any tinge of green. A silica skeleton remains undissolved.

With nitrate of cobalt, dirty-rose colour; the fused edges purple.

From the last result, the grey substance appears to contain a considerable portion of magnesia.

I hope before long to give the analysis of the three preceding minerals.

Article VII.

Abstract of the Report on M. Rousseau's Memoir respecting a new Method of measuring the Power of Bodies to conduct Electricity. By MM. Ampere and Dulong.*

M. Rousseau, who has been occupied several years in the construction of dry voltaic piles, with the view to discover the circumstances which modify the energy and duration of their action, conceived the idea of employing those instruments to appreciate the different degrees of conducting power of the substances arranged in the class of bad conductors of electricity. For this purpose he has contrived the apparatus we are about to describe. The dry pile, which forms the principal part of it, is made of discs of zinc and tinsel, separated by pieces of parchment, soaked in a mixture of equal parts of oil of poppies, and essence of turpentine; the whole is covered laterally with resin to prevent the contact of the air. The base of the pile

* From the Annales de Chimie.

communicates with the ground. Its upper extremity may be connected by a metallic wire with an insulated vertical pivot, carrying a weakly magnetic needle, balanced horizontally. On a level with the needle, and distant from the pivot, about half the length of the latter, is a metallic ball, also insulated, but communicating with the pile. It is evident that by this arrangement, the electricity accumulated at the upper pole of the pile, is communicated to the needle and the ball, and consequently repulsion ensues, tending to separate the needle, which is moveable, from the ball which is stationary. If we place the pivot and the ball in the magnetic meridian, the needle touches it, and remains at rest as long as the apparatus is not connected with the pile; but the instant the communication is established between them, the needle is repelled, and after some oscillations takes its position of equilibrium, depending on its magnetic power and the energy of the pile. These two quantities remain constant for a considerable time, with the same apparatus, as may be ascertained, by determining the angle which the needle makes with the magnetic meridian, after it has assumed a fixed position, by means of a divided circle adapted to the cage which covers it. A simple conducting needle suspended by a metallic wire of proper diameter and length, might be substituted for the magnetic one; but M. Rousseau's apparatus is much more convenient, and sufficiently sensible for the kind of effect which it is his object to measure.

To use it for ascertaining different degrees of conducting power, it is sufficient to place the substance submitted to experiment in the electrical current, taking care that the thickness which the electricity has to pass through be always equal. If the flow of the quantity of electricity necessary to produce the greatest deviation be not instantaneous, the time required by the needle to assume its fixed position, may be taken as the measure of the degree of the conducting power of the substance employed.

To submit liquids to this kind of examination, M. Rousseau places them in small metallic cups, communicating by their foot with the needle and the ball: he then places in the liquid one of the extremities of the metallic wire, covered with gum lac, that the same surface of metal may always be in contact with the fluid, and measures the duration of the needle's motion from the moment when the communication is established with the pile by the other extremity of the wire.

By submitting the fixed vegetable oils employed in the arts and in domestic economy to this kind of proof, M. Rousseau has established a very singular fact, which may be useful in commerce; it is that olive oil possesses a very inferior degree of conducting power to that of all the other vegetable or animal oils, which nevertheless present, in all their physical proper-

ties, the strongest analogies to that substance. For instance, every thing being equal in both cases, olive oil required forty minutes to produce a certain deviation, while poppy oil, or the oil of the beech-mast, required only twenty-seven seconds to produce the same deviation. One-hundredth part of any other oil added to oil of olives reduces the time to ten minutes. It would, therefore, be easy to discover by means of this instrument the smallest traces of any oil fraudulently mixed with oil of olives.

If the proportion of the foreign substance be considerable, the difference of time necessary to produce the maximum of effect would no longer be sufficiently great, and could not be measured with sufficient precision to indicate the proportion of the elements; but the apparatus might easily be modified so as to adapt it to this kind of determination.

The solid fats are worse conductors than the animal oils, arising no doubt from the large proportion of stearine contained in the former; for M. Rousseau is satisfied, by comparative trials with stearine and elaine, prepared by M. Chevreul, that the conducting power of the latter much exceeds that of the former. The fat of an animal becomes a worse conductor in proportion to the age of the individual which afforded it.

By means of the same apparatus, we may also observe a notable difference between resin, gum lac, and sulphur, the most insulating of all known substances, and silk, crystal, and common glass.

M. Rousseau has not found any difference in the conducting power of liquids, whether spirituous or aqueous, acid, alkaline or neuter, the time required by the needle to arrive at the maximum of deviation being too short, in every case, to ascertain the inequality of its duration. But a modification of the apparatus, similar to that for determining the proportions in an oleaginous mixture, would easily appreciate that difference.

It would be equally possible, and very curious, to try the effect of the two kinds of electricity on different substances; all that would be necessary would be to place the two poles alternately in connexion with the ground. According to Ermann's results, it is probable that a difference would be found between some substances.

ARTICLE VIII.

Abstract of M. Bequerel's Paper on the Electro-motive Actions produced by the Contact of Metals with Liquids, and on a Process for ascertaining, by Means of the Electro-magnetic Effects, the Change which certain Solutions undergo by Contact with the Air. (Read before the Royal Academy of Sciences, April, 1824.)*

IN former papers presented to the Society, M. Bequerel had attributed the electrical effects observed during chemical action, solely to the play of affinities exerted between the combining bodies; concluding that during such action the alkali takes positive, and the acid negative electricity, and neglecting to take into the account the effect resulting from the contact of the acid with the platina cup which contained it, and that of the alkali on the jaws of the forceps (which were also of platina) in which it was held, an action, however, which must by no means be overlooked.

The apparatus which M. Bequerel employed in his present experiments is similar to the electroscope invented and described by M. Bohnenberger, in the Bibliotheque Universelle, Nov. 1820 (see also Annales de Chimie, 1821, vol. xvi.), but instead of two dry piles placed vertically, he uses only one placed in a horizontal position, on a wooden support; to each pole a metallic plate, about three inches long, is fixed vertically, between which the gold leaf is suspended, in contact with the lower plate of the condenser; the condensing plates being nine inches in diameter. The delicacy of this instrument is such that it is sensible to the action of an excited glass tube at the distance of eight or ten feet.

A brass capsule, containing an alkaline solution, was placed on the upper plate of the condenser, and a communication established between it and the ground by touching it with the finger, or a moistened slip of gold-beater's skin, the lower disc being also in connexion with the ground; in a few seconds after, the upper plate was removed, and the gold leaf flew to the positive pole; consequently the alkaline solution had become positive from contact with the copper, and the metal negative.

When sulphuric acid was substituted for the alkaline solution, the electricities were reversed.

To ascertain the electro-motive action of different metals by contact with acid and alkaline solutions, a capsule of the metal containing the solution was placed on the upper plate of the condenser; the lower plate was then touched with a slip of the

* From the Annales de Chimie.

same metal, and the liquid with the finger; thus the electro-motive action arising from the contact of the metal under examination with the copper was destroyed, and only the electricity which it had acquired by its contact with the solution remained on the upper plate of the condenser. It is sometimes necessary to place a slip of paper between the metal experimented on and the copper, for the apparatus is so sensible, that a very slight difference in the state of their surfaces would modify the electro-motive action.

Operating in this way, it was found that by contact with an alkaline solution, the metal, whenever its electrical state can be determined, becomes negative; and positive with an acid; but with silver, and in many other instances, the electro-motive action is too feeble to be rendered sensible.

These results confirm and extend the observations formerly made by Sir Humphry Davy on the electrical effects produced by the contact of metals with acids and alkalies, in a perfectly dry and solid state, between which there is consequently no chemical action; for they prove that similar effects ensue when the latter substances are in solution, and even when in some cases the contact is accompanied by incipient chemical action.

In order to understand what is the influence of the fluids interposed between the plates of the voltaic instrument, and whether it has any other action than that of a mere conductor to transmit the electro-motive action of the metals from one to the other, it is necessary to ascertain what happens when an acid or alkaline solution is placed between two dissimilar metals. For this purpose, the copper capsule, filled with either an acid or alkaline solution, was placed on the upper plate of the condenser, as before; the solution was then touched with a plate of zinc (taking care not to touch the copper with it), and the lower plate of the condenser with the finger, and after a lapse of twenty seconds, the upper plate was removed; the gold leaf flew to the positive pole; consequently the copper capsule had become positive.

The experiment was reversed by using a capsule of zinc filled with either solution; and the lower plate of the condenser was touched with a plate of zinc to destroy the electro-motive action between the capsule and the plate, and a plate of copper, held between the fingers, was immersed in the solution. On raising the upper condensing plate, the gold leaf flew to the negative pole, and consequently the zinc capsule had become negative. We see from these two experiments, that when zinc and copper are separated by an acid or alkaline solution, the copper becomes positive and the zinc negative; just the reverse of what takes place between these metals by simple contact.

"We have also," says M. Bequerel, "examined what takes place on the contact of a metal with a saline solution; as cop-

per with solution of sea salt; the copper becomes negative, and the solution positive. This result explains why a plate of copper in contact with zinc or tin, as lately ascertained by Sir H. Davy, is less acted on by the sea-water than when not in contact with an electro-positive metal. It cannot be denied, that two substances at the moment they combine are in different electrical states, and that there is a certain relation between those states and the chemical affinities. Now if we can modify those electrical states, it is almost certain that we shall also modify the play of affinities; but we have seen that a plate of copper, by contact with a solution of sea-salt, becomes negative; it follows that if we touch the same metal with an electro-positive metal, the copper will be placed between two bodies, each tending to impart the same kind of electricity, a condition which we know will tend to annul the electro-motive action of the copper on the solution of sea-salt. Thus, according to the electro-chemical theory, circumstances are so arranged as to weaken the chemical action of the solution of sea-salt on the copper."

The memoir concludes with pointing out a method by means of electricity, of ascertaining the changes which some solutions experience by contact with the air.

Dissolve iron in nitric acid; filter the solution, and immerse into it two laminæ of platina, each communicating with one of the extremities of the wire of the galvanometer; leave one of the wires in the solution, withdraw the other, and again immerse it; it will be positively electrified.

The nitrates of copper and lead give similar results for a short time; nitrate of zinc produces no such effect.

When the experiment is made in an atmosphere of hydrogen, no electrical current is established, though all circumstances, except the want of contact with the atmosphere, are precisely similar in both experiments.

"Hence the contact of atmospheric air is indispensable to the production of the electrical current by the immersion of platina laminæ in several fresh-prepared nitrates; but what is the modification that is instantaneously effected in the liquid adhering to the surface of the lamina withdrawn from the solution? We can, to a certain extent, explain this: The solution of a metal in nitric acid gives rise to several compounds: take iron, for instance; first deutoxide of azote is formed, and soon after nitrous acid, a protonitrate and a deutonitrate; by degrees the deutoxide of azote passes to the state of nitrous acid, the protonitrate to that of deutonitrate, and, after a certain time, only deutonitrate remains in the liquid. According to this statement, when we withdraw one of the platina laminæ from the solution, the liquid which adheres to it immediately, in consequence of the thinness of the stratum, experiences changes from

the action of the air, which do not take place till after several hours in the bulk of the solution. It follows, therefore, that when we re-immerse the lamina, we bring in contact two dissimilar liquids, and nothing in that case opposes the production of an electrical current.

"On the other hand, since the immersion of platina laminæ in a solution of nitrate of zinc does not produce any current, although it contains deutoxide of azote and nitrous gas, it is probable that this may be owing to the nitrate not suffering any change by contact with the air, in consequence of the metal being capable of forming only one oxide."

Article IX.

On a deoxidating Property of the Vapour of Water. By C. H. Pfaff.*

It was remarked by Hermbstadt, while making the experiments from which he deduced the existence of *a peculiar colouring principle* in sea-water, and its superincumbent atmosphere,† that if that liquid be boiled in a retort, and if, by means of a glass tube attached to the beak of the retort, the gases and aqueous vapour evolved be made to pass through a solution of nitrate of silver, the latter by degrees assumes the colour of *red* wine, and at the end of 24 hours, a *brownish-yellow* coloured sediment is deposited. I observed the same appearance, on repeating this experiment with sea-water from the bay at Kiel. As, however, I had reasons for suspecting that this change is not occasioned by any peculiar gaseous constituent, I prepared an artificial mixture of solutions of the muriates of magnesia and soda, in the proportions which constitute sea-water, and on making the experiment with this, I still obtained the same result. I observed also that the colour imparted to the solution of nitrate of silver at the beginning, and towards the conclusion of the experiment, is different: at first it is a weak violet, but after the experiment has gone on for some time (provided there be a sufficient quantity of the metallic salt in the vessel through which the vapours pass), it has a considerable infusion of reddish-brown. Hence I considered it not unlikely, that in these experiments there are two distinct causes which produce discoloration. This induced me to repeat the experiment in a variety of ways; which at last conducted me to the following very interesting results.

The experiments themselves are extremely simple. The

* Schweigger's Journal für Chemie und Physik, xxxvi. 68.

† This opinion was refuted by Pfaff in a small pamphlet, entitled *Das Kieler Seebad verglichen mit andern Seebädern an der Ostsee und Nordsee*, Kiel, 1822.

liquids were boiled in clean glass retorts, and great care was taken to prevent any portion of them from being carried over mechanically in the state of drops. The solutions on which the action of the gases and vapours expelled by boiling was to be determined, were contained in Woulfe's bottles, and, in general, the vapours passed through two or three of these in succession. The tubes of communication between the retort and the first bottle, and between the bottles themselves, were plunged to a sufficient depth in the solutions.

1. The *mere vapour of pure* distilled water when passed through a transparent solution of nitrate of silver, has the property of communicating to it a discoloration, in proportion as it heats the solution to the temperature of ebullition; and the intensity of this discoloration varies from yellow to dark-brown, according to the concentration of the solution, and to the length of time during which it has been exposed to the action of the vapour.

2. This discoloration is inconsiderable, so long as the solution of nitrate of silver remains under the boiling point, but it becomes exceedingly striking, the instant ebullition commences. The colour which first appears is yellow, but it rapidly becomes darker. The colour of the solution of nitrate of silver, when sufficiently diluted, has a close resemblance to red wine.

3. In the same manner, the solutions of nitrate of silver in the remaining bottles may be discoloured; because the vapour, after heating the liquid contained in one bottle, passes over into the next, and raises its temperature also to the point of ebullition.

4. This discoloration is caused by a deoxidation of the nitrate of silver, and except that it takes place with much greater rapidity, it is similar in all respects to the effect produced by light. In proof of this we may mention, *a*. The similarity of the colours with those produced by the action of mere light. *b*. The complete removal of the colour, and restoration of transparency, by the addition of nitric acid. *c*. The similar deoxidizing effect of the vapour of water upon other metallic solutions, which are easily deoxidized, either by light, or by some chemical action. *d*. The disengagement of *oxygen gas* during the process.

5. The most convincing of all proofs is furnished by a solution of *muriate of gold*. A solution of this salt so much diluted as scarcely to retain a shade of yellow, when heated to the boiling point by a stream of the vapour of water, acquires a beautiful blue colour, exactly similar to the colour produced in it by tincture of nutgalls, oxalic acid, &c.

6. After the expulsion of the atmospheric air, I collected the gas which was disengaged in a constant stream of minute bubbles, from the boiling-hot solution of nitrate of silver. It proved to contain a considerably greater quantity of oxygen than common air: 100 volumes of it mixed with 100 volumes of nitrous gas, sustained a diminution amounting to 91, whereas common air sustained a diminution of only 80.

7. Of the other solutions whose colour is changed by deoxidation, I examined *acetate of silver*, which became discoloured, like the nitrate, but more feebly; and *muriate of platinum*, which underwent no alteration.

8. Sea-water and solutions of common muriate of soda and of muriate of magnesia, when boiled, and when the disengaged vapour is passed through a solution of nitrate of silver, occasion appearances of a more complicated nature. In this case, the metallic solution is decomposed, not merely by aqueous vapour, but by the muriatic acid which is disengaged from the boiling liquid; and a quantity of chloride of silver is formed, which the action of the aqueous vapour subsequently renders violet-coloured, provided it at the same time raises the temperature of the solution of nitrate of silver to the boiling point. Should any portion of the nitrate of silver be left undecomposed, it is deoxidized by the vapour of water, and a yellow or brown colour is developed, which mixes with the violet, and imparts to it various modifications of shade. My original opinion, therefore, that the change of colour is caused by the muriatic acid which distils over along with the water, is confirmed, but at the same time restricted, by this experiment. Muriatic acid is also disengaged from a boiling solution of the common muriate of soda, although in much smaller quantity, than from a solution of muriate of magnesia. Whether in the case of muriate of soda, the acid proceeds from a small residue of muriate of magnesia, or muriate of iron, I do not venture to determine. Neither of the bases (soda, magnesia) appears to pass over: at least, the distilled water leaves no residue when evaporated.

9. This yellow, reddish-brown, or dark-brown coloured solution of nitrate of silver, produced in so remarkable a manner by the deoxidizing action of aqueous vapour, retains its colour for a long time unaltered, but it at last deposits a dark-brown oxide of silver.

10. If previously to the introduction of aqueous vapour the solution of nitrate of silver be raised to the boiling point by the immediate application of heat, it does not completely retain its transparency after having been exposed as usual to a current of the vapour, but the discoloration which it sustains is greatly inferior.

The deoxidizing property of aqueous vapour, demonstrated beyond a doubt by the foregoing experiments, deserves to be still further investigated, and would, perhaps, already admit of some practical applications. It is my intention to continue my experiments on the subject. Before concluding, I may observe, that the vapour of water does not appear to produce any change upon a solution of corrosive sublimate, or upon solutions of the protoxide or peroxide of mercury in nitric acid.

ARTICLE X.

On the Transmission of Electricity through Tubes of Water, &c.

By Mr. C. Woodward.

(To the Editor of the *Annals of Philosophy*.)

SIR, *June 5, 1824.*

ON perusing the last number of your *Annals*, I observed a letter signed T. J., informing me "that the experiment of firing *loose* gunpowder by passing the charge of a leyden phial through tubes filled with water, and also on the conducting power of alcohol, ether, and acids, were made by a Mr. Lewthwaite, in May 1821; and are published in the eleventh volume of the Institution Journal:" the natural inference of which, I apprehend, is, either that I published some experiments as new, which were not so; or that I gave as my own, the experiments of another.

If T. J. will refer to my letter, I think he will perceive that my object was to offer a *theory* in explanation of a singular phenomenon, and not merely to state the fact of the inflammation of loose gunpowder, or the conducting power of alcohol, ether, and acids. For this purpose I introduced the subject as briefly as I could, and then enumerated the experiments, which led me to conclude that the theory I offered was the correct one.

"It was (observes T. J.) from reading this letter that I became acquainted with the experiment." This, however, was not the case with myself, as the effects of electricity on loose gunpowder, when transmitted through tubes of water, were communicated by me to Mr. Lewthwaite some time previous to the publication of his letter.

It is extremely painful to speak of one's self; therefore, in my last communication, I avoided any allusion to what I had done elsewhere; but considering myself now called upon to explain, allow me, through you, to inform T. J. that I introduced the experiment in my concluding lecture on Electricity, at the Surry Institution, in December 1820; observing at the same time, that I could not offer any theory in explanation, the experiment having been but a few hours communicated to me by my much esteemed friend, Mr. Knight Spencer, the Secretary to the Institution.

Early in 1821 I instituted a series of experiments to ascertain the cause; and, although I had then no explanation to offer, my experiments would have been presented to the public through the medium of one of the philosophical journals, had not the appearance of Mr. L.'s letter in the Institution Journal

superseded the necessity of it.—In 1823 I again introduced the subject in my course at the Surrey Institution—when the experiments and theory noticed in my former letter to you, were offered in explanation—and I was induced to suppose my communication would not prove unacceptable, by the recent inquiries of some scientific friends who were anxious to know if I could explain the cause of so singular an effect—among whom was Mr. Lewthwaite, the writer of the letter alluded to by T. J.

I now turn to a more pleasing part of the subject, that of investigating experiments.

"Would suggest (continues T. J.) that Mr. W. should repeat the experiment with the water tube. I am disposed to think Mr. W. is in error, when he says the intensity (measured we are to suppose by a pith ball electrometer), indicated, was from 10° to 15°." The supposition in the parenthesis is perfectly correct, and I can assure T. J. I have too often repeated the experiment, and made too many notes upon the subject in conjunction with my electrical friends, to be in error. I have *very* frequently succeeded in the experiment with a quart jar, when the electrometer has indicated an intensity of only 10°, but not invariably; hence I stated in my letter, "an intensity of from 10° to 15° is *generally* sufficient." Had I noticed all the minute peculiarities I have observed on this head, my communication would have been much too long for insertion, and as no particular point turned upon the question, I considered it sufficient to express myself in terms to be understood by an Electrician, without unnecessarily intruding upon your valuable pages. I must, however, inform T. J. that the success of the experiment, with a low degree of intensity, will greatly depend on the *quality of the gunpowder*, as well as the care taken to prevent the dissipation of the electrical fluid, for with very coarse powder I have been unable to perform the experiment at all.

T. J. lastly observes, "it would have been more satisfactory if the degree at which the jar spontaneously discharged itself, had also been stated." This I confess myself at a loss to comprehend, for I have always found the spontaneous discharge of a jar, when mounted in the usual way, to depend as much upon what may be termed casual circumstances, as any experiment connected with electricity. At one time I have seen a spontaneous discharge take place at 50°; at another, the same jar, with the same electrometer, has been charged to 90°, without a spontaneous discharge. This suggestion, if reduced to practice, would be rather an expensive one to me, as my jars are all furnished with internal paper rims, according to Mr. Singer's plan—the metallic rods communicating with the inner coatings are passed through stout glass tubes, cemented

in the caps of the jars, and the uncoated surfaces are var nished, so that a spontaneous discharge seldom or ever takes place without fracturing the jar.

I am aware that the Pith Ball Electrometer is a very uncertain standard; and if my theory had depended on the degree of intensity required to produce the effect with a jar containing a given extent of coated surface, I should have used *the balance electrometer*, invented by Mr. W. S. Harris, of Plymouth, a description of which may be seen by referring to page 77 of "Observations on the Effects of Lightning on Floating Bodies, by W. S. Harris. London, 1823."

I trust T. J. will continue the experiments, which, when well matured, he has promised shall be submitted to your consideration; and, if he thinks I am in error, or has discovered any facts which may militate against my opinions, I will either most cheerfully answer them in the true spirit of philosophy, which teaches us "to agree to differ," or I will prove to him that I am not wedded to any system, and that no one would more readily sacrifice a favourite theory, at the shrine of truth, than myself. Should he, on the other hand, require any information on a subject which has been for some years my favourite study, I shall feel much pleasure in making the communication, if in my power. I am, Sir, your obedient servant,

CHARLES WOODWARD.

ARTICLE XI.

Some Observations on Mr. Penn's Theory concerning the Formation of the Kirkdale Cave. By James Smithson, Esq. FRS.

(To the Editor of the *Annals of Philosophy*.)

SIR, *June* 10, 1824.

No observer of the earth can doubt that it has undergone very considerable changes. Its strata are everywhere broken and disordered; and in many of them are enclosed the remains of innumerable beings which once had life; and these beings appear to have been strangers to the climates in which their remains now exist.

In a book held by a large portion of mankind to have been written from divine inspiration, an universal deluge is recorded. It was natural for the believers in this deluge to refer to its action, all, or many, of the phenomena in question; and the more so as they seemed to find in them a corroboration of the event.

Accordingly, this is what was done, as soon as any desire to account for these appearances on the earth became felt.

The success, however, was not such as to obtain the general assent of the learned; and the attempt fell into neglect and oblivion.

Able hands have lately undertaken the revival of this system; Mr. Penn has endeavoured to reconcile it with the facts of the Kirkdale Cave, which appeared to be strongly inimical to it.

Acquainted with Mr. Penn's opinions only from the "Analysis of the Supplement to the Comparative Estimate" in the Journal of the Royal Institution for January, not having seen this Supplement itself, the Comparative Estimate, nor even a review of this in a former number of the Journal, and knowing of Mr. Buckland's *Reliquiæ Diluvianæ*, only the account of the Kirkdale Cave published in the Philosophical Transactions for 1822, I have hesitated long about communicating the present observations, which presented themselves during the perusal of the above-mentioned slender abstract.

I have yielded to a sense of the importance of the subject in more than one respect, and of the uncertainty when I shall acquire ampler information at more voluminous sources—to a conviction that it is in his knowledge that man has found his greatness and his happiness, the high superiority which he holds over the other animals who inhabit the earth with him, and consequently that no ignorance is probably without loss to him, no error without evil, and that it is therefore preferable to urge unwarranted doubts, which can only occasion additional light to become elicited, than to risk by silence to let a question settle to rest, while any unsupported assumptions are involved in it.

If I rightly apprehend Mr. Penn's ideas, they are these:

Secondary limestones were originally in a soft state.

The waters of the deluge while elevated above England, deposited on it a layer, or bed, of "a soft and plastic" calcareous matter.

On their departure from the earth, by flowing away towards the north, they floated over England the carcases of a number of tropical animals, clustered together into great masses.

These masses became buried in the calcareous mud.

On the sinking of the waters of the deluge below the surface of England, the bed of calcareous mud began to dry, and on doing so completely, became the present Kirkdale rock.

The clustered animal bodies enclosed in the calcareous paste, by putrifying, evolved a great quantity of gas, which forced the limestone paste in all directions from them, and thus generated the Cave in which Mr. Buckland found their bones.

Soft State of Secondary Limestones.

That secondary limestones have been in a state to admit fo-

reign bodies into their substance, their existence in it is evidence.

Every shell and stone on the beach tells by its rounded form the attrition to which it is subject at each flood and ebb of the tide; and that a subtil powder is abraded from it which is collected somewhere.

From the immense multitudes of marine bodies which exist in some of these limestones, from others consisting in fact entirely of them, from in general little or nothing but calcareous matter being present, it becomes highly probable that it is to the calcareous part of marine animals, more or less comminuted, that secondary limestones owe their origin.

Deposition of the Calcareous Mud.

The waters of the deluge had not, surely, either a duration or power, to obtain the matter of this supposed layer of mud.

No shores any longer existing, shells could not be pulverised by the beat of the wave, for it is not deep under water that such destruction is effected; nor, was it so, would the short period of a year have been sufficient to produce the material of all the secondary limestones of the earth!

To have harrowed up this matter from the depths of the ocean, would have required an agitation of the waters, which nothing warrants us in giving to them, which every thing denies their having had.

No hurricanes, no tempestuous winds, no swollen billows, are recorded. To drown mankind they were superfluous. A wind having arisen at the termination of the calamity tells that none existed before; and this wind must have been a most gentle one, a very zephyr. A vessel, bulky beyond all the efforts of imagination to figure, so laden, so manned, could not have lived in any agitated sea, least in one which out-topped the Alps, and the Andes, all that could curb its fury, and mitigate its violence.

Had the ark not foundered, which is impossible, what yet had become of the millions which its sides enclosed? Few had survived to repair the effects of the divine wrath.

The waters must have been at rest when the ark continued stationary for many months on the mountains of Ararat.

Nor, do the agitations of a sea extend far below its surface. What navigator has told of the storm in which the sea became thick with its own sediments?

But had such a deposit been made on our island, it would not have continued on it. Standing like a little turret in the bosom of the waters, each agitation of them would have precipitated part of it down its sides. Their gigantic tides must alone have washed it away, and on the rush of their final departure, not a vestige of it could possibly have remained behind.

If the waters of the deluge placed a bed of calcareous matter on England and Germany, they must have done so over the entire earth. It must have been an universal stratum.

Yet so total was the deficiency of it at Botany Bay, that the first settlers, for the very little lime which a few structures of immediate necessity required, were compelled, though spare as were the hands, and much as they were wanted for other purposes, laboriously and tediously, to collect shells along the beach. Where a limestone nodule was so anxiously sought and could not be found, great strata could not be near.

But the sediment of the deluge waters would not be mere calcareous matter. It must have consisted of every thing which they could receive, suspend, and deposit.

If over the earth were spread such a layer of mire, Noah and the animals could not have landed upon it. Or had they not sunk into it and been smothered; where yet had the weak found refuge from the voracious; where had the herbivorous found food?

What a time must have elapsed before Noah could cultivate the vine! Nor is it from such a soil that the wine would have intoxicated the holy Patriarch. Had things so been, Ham never had offended, nor Canaan incurred the fatal curse.

Sinking of the Bodies into the Mud.

Supposing, however, such a bed of "soft and plastic" calcareous matter deposited by the waters on England, the immersion of the bodies into it is of no small difficulty.

Animal bodies bloated with gas from decay, which water had "floated on its surface," are not easily conceived to have displaced a stony powder of a specific gravity of 2·7, and to have fallen below it.

"Turbulent vortices," which are imagined to have lent their aid on the occasion, would have disseminated the clustered animals, and dispersed the powdery stratum.

That the bodies should in every case have descended into the calcareous pulp, in one unbroken group; that in none a fragment, even a lock of hair, should have parted from the putrid mass, and stopped by the way, cannot certainly plead probability in its favour. Yet what cabinet shows even the slenderest bone of a water-rat bedded in the solid stone? What limestone stratum has astonished the learned, by presenting them, in its substance, with an antediluvian hyæna's bristles, or lion's mane?

Formation of the Cave.

If the limestone pulp was too thin, the gas would pass through it and escape, and the pulp fall back upon the bodies; if too thick, the elastic force of the gas would be insufficient to repel it from them. A precise point of induration, at

which it would at once yield and resist, was indispensable. This exact condition would but rarely occur; would, at least, often not do it, and consequently bodies buried in the solid rock must be frequent, if not most so.

It is incredible that in every case the gas should have driven away from the bodies the whole of the mud in contact with them. Some of the mud must have insinuated itself between the several individuals of the cluster, some have penetrated by the mouth, by lacerations, into the cavity of the bodies, and isolated pieces of rock must now occur among the bones, bearing the impression of the parts with which they had been in contact; as at Pompeii, indurated ashes presented the cast of a woman's breasts.

As the parts receded from the bodies, it would carry with it some adhering fragments of them—bones, teeth, hair, feathers; and which would now be fixed to the sides and roofs of the caves.

Bodies which had been previously putrefying for twelve months in a tropical temperature, would not probably have still afforded, after their interment, sufficient gas for the supposed purpose. From some experiments, made a great number of years ago, on the decay of animal muscle confined over mercury, I am inclined to believe, that in no case, when secluded from oxygen, is any great volume of gas evolved by it. Subjected to the imagined pressure, would the matters of the gases have been able to expand to the elastic form? Would they not rather have assumed the fluid one?

Under these circumstances, would the muscular part of the bodies have entirely disappeared? Would not some portion of it have altered to adipocire? In such a state some of it must at least sometimes be met with.

That fish have, in some cases, been inclosed in strata, invested with all their muscular part, seems indubitable, from the presence of the scales; but they are scattered singly through the stratum, and have blown up no caves round themselves.

Indeed, the clustering of the quadrupeds during their voyage, appears to be by no means a certain event. If they sunk below the surface, they would sink to different levels; borne on the surface, they might assemble together, but no adherence would take place between them, and upon the slightest impulse they would part again.

If the bodies were deposited with their integuments, the bones must be nearly all of them entire. How should they have become broken, enveloped in a soft mass, rendered additionally elastic by the gases of a putrefying state, and floating on a sea which, high above all land, bore them out of the reach of every means of concussion, especially become shivered as are of those of the cave? The force which could thus

destroy the bones, had reduced the muscular matter to pulp, and the waters had carried it off, and the cave had had no efficient cause.

If the bodies were deposited entire, every bone of each must be forth coming, and its complete skeleton admit of being mounted.

Between "the animal remains discovered buried singly in strata of gravel and clay, and those found in multitudinous masses in the cavities of rocks," there exist the important differences of the former not being in caves, and of the strata in which they occur being fresh-water ones. These remains may consequently be supposed those of animals washed from heights by inundations, and buried in the earthy matter transported with them.

Nor can the bones of the cave be assimilated to the "shells kneaded into the limestone rock of Portland." For the comparison to hold, the bones must be "kneaded into the limestone rock" as the shells are, and as are the bones in the Stunsfield slate, which have been placed in it by the sea.

If the stalactites had been produced by the descent of portions of the calcareous pulpy mass yielding to gravity, they would, like the stalactites of lava, formed in this way, have the texture of the rock. The stalactites of limestone strata are clusters of crystals, which have generated from solution in water.

Induration of the calcareous Stratum.

The calcareous paste is supposed by Mr. Penn to have petrified by simple drying; and on this supposition much of the hypothesis concerning the formation of the Cave reposes.

Experiments will convince that a paste of calcareous powder and water does not dry to marble, but to whitening. An indurating faculty must not be attributed to time, it has it not. Chalk strata cannot be assigned a less age than the rocks of Yorkshire, and they have not dried to stone, nor seem hastening to become such.

Each particle of powder is a diminutive pebble, and an intervening cement is required to connect it with the neighbouring ones.

Carbonate of lime dissolved in water by means of an excess of acid is the element of agglutination, which nature has in these cases made use of. The acid solvent exhales or becomes saturated, and the neutral salt, ceasing to be soluble, crystallizes on the particles of the powder.

It is thus that the sands of the Calabrian shores are consolidated. The sea water loaded with the calcareous salt, carries it into them. It cannot be by drying since they are wetted

by every wave; and sand wetted with ordinary sea water and dried is not converted into millstone. The great hardness is due to the silicious part.

I brought a mass of sand from the sea at Dumbarton, inclosing a recent razor shell with its epidermis on it, and fragments of coal, cemented to stone by carbonate of lime, so that the calabrain process takes place on that coast.

In limestones consisting of considerable-sized fragments of shells, the sparry cement which connects them is perfectly evident. It is this cement which appears as regular crystals where cavities occur in the mass too large to have been filled by it.

Beds of sediment can by this means become rock at the utmost depths of the ocean, and it is in all probability there that most of them have done so. The workings of contiguous volcanos have supplied the carbonic acid.

Oolites have been evidently formed in a sea much loaded with dissolved carbonate of lime, and which on the escape of the dissolving acid has crystallized round floating particles. When the weight of the grains has become such as to occasion their subsidence, they have been cemented together, every thing taking place in all respects as in the case of the pisolites of Carlsbaden. The Kirkdale rock being composed of oolites must have had this origin.

Such a formation cannot be assigned to the time of the deluge. Besides the violence of bringing within the compass of a few months, operations whose accomplishment seems to have required centuries of centuries, the necessary conditions must have been wanting. Had not all the volcanos become extinguished, they could not, and in such a time, have poured forth carbonic acid to saturate the immensity of its waters; and it is also utterly impossible to believe that the beings in the ark, already not a little inconvenienced for respiration, could withstand the suffocating effluvium.

Coming of the Animals by Sea.

Of the animals having been tropical ones no testimony is offered. The elephant of Siberia being now ascertained to have been a very hairy animal may be supposed to have been a northern one, and if there were formerly northern elephants, there may have been northern hyænas and northern tigers.

If the bodies were brought by water, no reason appears why they are, with the exception of a few birds, exclusively those of quadrupeds. Reptiles, insects, trees, even fish, for all of them must have perished from the mixture of salt and fresh water, must have entangled in the clusters.

As the bodies must have been macerated for about a year in the tropical seas, before the retreat of the waters transported

them towards the north, those of the smaller animals, as the water-rats, must have been so completely decayed as to be reduced to the bones solely, which water would not float.

The voyage from the tropics of the balls of album græcum in an entire state, is what will not, under any circumstances, be easy to admit; to suppose it amidst "turbulent vortices, by which the framework of the animals was shattered, dislocated, fractured within the integuments," reduced to splinters, is utterly impossible. The entire state of the balls of album græcum, and the extremely fractured one of the bones, are totally incompatible on Mr. Penn's system. And such an ablution would not have left in these balls a trace of the triple phosphate.

But quadrupeds are not the only animals of tropical features found in northern latitudes. Every shell in the strata, the nautili, the cornu ammones, the belemnites, the anomia, are now as foreign to the surrounding seas, as are the others to the land. If one then came from afar, both did.

What must have been the mass and impetuosity of the wave which could buoy a huge oyster, a massive brain stone, from the equator to the British Islands, and at an elevation to deposit it on Shotover Hill, or at Kingsweston? Such waves had tumbled down the mountains of the earth, shivered its islands and its continents, and choked up the bed of the ocean with their ruins. Surely it is a far less difficulty to "bring the climate to the exuviæ, than the exuviæ to the climate."

The existence together of the bones of many species does not necessitate the conclusion of the animals having been associates in the cave. If hyænas "do not always resort to the same den," neither is it probable do other wild beasts. A succession of inhabitants is admissible.

Nor is it required to believe that any of the animals whose bones were found in the cave died there. If hyænas collect bones round their dens, it must be allowed not very improbable that they sometimes, often even, carry them a little further. Alarmed by the roar of a more mighty devourer, or even by that of one of equal strength, it seems natural for them to retreat with their spoil to their last refuge. Why, but to be able to do this, do they bring them near their dens?

The smallness of the cave's mouth, admitting it to have been always what it now is, would indeed oppose the idea of elephants having walked into it, but no entire skeleton requires the admission of their having done this; and hyænas who feed on putrid carcases, may have found no difficulty in parceling such; or they may have collected "the Bushman's harvest," or the bones may have been carried into the cave by animals more powerful than hyænas.

If animals as ravenous of bones as hyænas are said to be did not, in any hour of dearth, devour those of the water-rats, it may

be because those became tenants of the cave only when the water had expelled the hyænas. It is alike improbable that animals of such contrary habits should dwell together, and that hyænas should carry so diminutive a prey as a water-rat, to their den to devour it.

The small quantity of the album græcum can afford no argument against the animals who produced it having lived in the cave. So brittle a substance could not last long under the trample of numerous animals of such bulk. The water which subsequently entered the cave may have destroyed a part. The existence of any is a strong circumstance in favour of the supposition of their having lived in the cave, and such as it would scarcely have dared to hope for, in its support.

If bones of quadrupeds are found inclosed in no rocks but limestone ones, which it may, however, require more extended observation to establish, the reason may be, that in no other rocks are caverns, in which wild beasts can take shelter, so common. These are likewise the only rocks in which the formation of stalactite would close the openings, and preserve the bones through a long course of ages, and so as to have reached our times, from the decay and all the accidents to which in an open cave they would be exposed.

Of the Deluge.

Should every argument which has been adduced to establish that the animals were not brought from remote regions by water, that they lived and died in the countries in which their remains now lie, have appeared insufficient for the purpose, yet, that it is not to the Mosaical flood that their existence, where they now are, is to be referred, two great facts appear to place beyond controversy.

One is the total absence in the fossil world of all human remains of every vestige of man himself and of his arts.

The magnitude of the chastisement, the order of nature subverted to produce it, proclaim the multitudes of the criminal. Human bodies by millions must then have covered the waters; they must have formed a material part, if not the principal one, of every group, and human bones be now consequently met with everywhere blended with those of animals.

Objects of human industry and skill must likewise continually occur among the bones. Of the miserable victims of the disaster numbers would be clothed, and have on their persons articles of the most imperishable materials; and the dog would retain his collar, the horse his bit and harness, the ox his yoke. To men who wrought iron and bronze, who manufactured harps and organs, these things must have been familiar.

But more; embalmed within the substance of the diluvian mud, entire cities, with their monuments, with a great part of

their inhabitants, with an infinity of things to their use, would remain. Every limestone quarry should daily present us with some of these most precious of all antiquities, before which those of Italy and Egypt would shrink to nothing.

How greatly must we regret that this is not the case, that we must relinquish the delightful hope of some day finding in the body of a calcareous mountain, the city of Enoch built by Cain, at the very origin of the world, with what awful sentiments had not present generations contemplated objects which once had been looked upon by eyes which had seen the divinity!

The other great fact which forcibly militates against the diluvian hypothesis is, that the fossil animals are not those which existed at the time of the deluge. The diluvian species must have been the same as the present. The multifarious wonders of the ark had for sole object their preservation; while of the fossil kinds, not perhaps one, or quadruped, or bird, or fish, or shell, or insect, or plant, is now alive.

"Amazing proofs of inundations at high levels" are appealed to. Had they being, of the deluge they could at most speak but to the existence; on its influence in the contested cases, they would be silent; but it appears that this stupendous prodigy,

> "Like the baseless fabric of a vision,
> Left not a wreck behind."

Of the occurrence of marine depositions at great altitudes, the elevation of the stratum by volcanic efforts, furnishes a far more easy solution than the elevation of the sea, as it refers the phenomenon to a natural cause, and does not require the immediate interposition of the divine hand; and the ruptured state and erect position of the strata on all these occasions, testify strongly in favour of the simpler supposition.

To collate the revered volume with the great book of nature, and show in their agreement one author to both, was an undertaking worthy of the union of piety and science. If the result has not been what was anticipated; if we look in vain over the face of our globe for those mighty impressions of an universal deluge, which reason tells us that it must have produced and left behind itself, to some cause as out of the natural course of things as was that event, must this doubtless be attributed.

By his entering into a covenant with man and brute animals, and having for ever "set his bow in the cloud," as a token that the direful scene should never be renewed, the Creator appears to have repined at the severity of his justice.

The spectacle of a desolated world,—of fertility laid waste,—of the painful works of industry and genius overthrown,—of infantine innocence involved in indiscriminate misery with the hardened offender,—of brute nature whose want of reason precluded it from the possibility of all offence, made share in the

forfeit of human depravity, may be supposed to have touched his heart.

Under the impression of these paternal feelings, to obliterate every trace of the dreadful scourge, remove every remnant of the frightful havoc, seem the natural effects of his benevolence and power. As a lesson to the races which were to issue from the loins of the few who had been spared,—races which were to be wicked indeed as those which had preceded them, but which were promised exemption from a like punishment, to have preserved any memento of them would have been useless.

To a miracle then which swept away all that could recall that day of death when "the windows of heaven were opened" upon mankind, must we refer what no natural means are adequate to explain.

ARTICLE XII.

ANALYSES OF BOOKS.

An Epitome of Chemistry, wherein the Principles of the Science are illustrated in 100 *Entertaining and Instructive Experiments, &c. &c.* By the Rev. John Topham, MA. (of St. John's College, Cambridge) Head Master of Bromsgrove Grammar School, Worcestershire. Second Edition. 24mo. pp. 134.

CONTRARY to the expectations we had formed when we first saw this publication, it has (according to the title page at least) reached a second edition; we consider it, therefore, proper to exhibit its true nature to the public, and to warn them of the numerous errors which it contains:—errors greater in number and importance than in any work of the same size that ever appeared on the subject of which it treats.

We shall not pretend to go minutely through the book; a few passages, taken almost at random, will be sufficient to show the nature of the work, and that the author, without intending to be original, is so greatly in error, that he does not possess even the slender requisites for a copyist.

With respect, first, to chemical action, it is stated, in p. 4, that "chemical action will not take place between two bodies, except one of them be in a fluid state, or at least contain water." Now this is not the fact; numerous examples might be given of the contrary, but one will suffice, viz. the mutual action of lime and muriate of ammonia. In p. 5, it is asserted that "if two bodies, x and y, unite in the proportion of 4 to 6, then these numbers express the weight of their atoms." This again is an error; oxygen and phosphorus unite in the proportion of 4 to 6, but these numbers do not express the weights of their atoms; they only show that phosphorus combines with two-thirds of its

weight of oxygen, but the weight of the atoms depends upon that of the standard assumed: thus the weight of an atom of hydrogen being 1, that of oxygen is 8, and phosphorus 12, but an atom of hydrogen being 0·125, oxygen is 1, and phosphorus 1·5.

"When combination takes place between two bodies in various proportions, the numbers indicating the greater are exact simple multiples of that denoting the least. Thus 100 parts of carbon unite with 132$\frac{1}{2}$, or 265 parts of oxygen, and no other. Again, 100 parts of sulphur unite with 50, or 100, or 150 parts of oxygen; and in the intermediate ones no combination ensues."

Now it happens that the greatest proportion is sometimes not a multiple, but one-half more than the least; this occurs with respect to iron, of which 28 parts unite with 8 of oxygen to form protoxide, and with 12 to form the peroxide. Again, the exact quantity of oxygen with which 100 of carbon unite are 133 to form oxide of carbon and 266 to form carbonic acid, but there is an intermediate compound, namely, oxalic acid, composed of 100 carbon and 200 oxygen. Once more; 100 of sulphur unite with 125 of oxygen to form hyposulphuric acid, as well as with the three proportions above stated.

In p. 12 we have a marvellously easy method of making sulphuric acid; sulphur "by combustion in atmospheric air over water, unites with oxygen, and forms *sulphuric acid*." How foolish then have our manufacturers been in using nitre at a vast expense! We must, however, I believe, for *sulphuric* read *sulphurous*.

Iodine appears also to have undergone a wonderful change of properties; according to Mr. Topham, it "is abundantly absorbed by water;" the fact is, that water absorbs about 1-7000th of its weight.

In the chapter on the alkalies, potash, soda, and ammonia are mentioned; and after incorrectly stating that the last "next to hydrogen gas, is the lightest known ponderable body," we are informed, that "the other alkalies are lithina, delphine, brucine, vauqueline," and then we are instructed that "the bases of the other alkalies [meaning the four last named], except vauqueline (which is of vegetable origin) have also been formed into amalgams with mercury, and are found to be metallic." From this we might conclude that delphia and brucia are not of vegetable origin, and that the seeds of stavesacre, and the bark of the brucia antidysenterica have been "found to be metallic." The sentence which we have last quoted is followed by "oxygen, therefore, in one proportion is the cause of alkalinity; in another (as will be seen) of oxidation; and in a *third* of acidity." It is difficult to conceive how so much error could have been crammed into so small a space. If these statements were true, then we may take any substance which is capable of uniting with oxygen; let it be hydrogen, sulphur, or potassium, and by combining them in

different proportions produce a mere oxide, an alkali, or an acid, with the same base. Mr. Topham will find that he has incorrectly stated with respect to different proportions of oxygen, what is true only with regard to different bases. This erroneous view of the case is also contained in the chapter on oxides, in which it is stated that "any simple substance, in union with a less quantity of oxygen than is necessary for the formation of an acid, is termed an oxide." Now acidity does not depend upon the quantity of oxygen, but upon the nature of the base which unites with it. Six parts of carbon combined with 16 of oxygen form an acid, but 6 parts of hydrogen combine with 48 of oxygen to form water. In the next chapter we again meet with the erroneous statement that sulphuric acid is formed by the combustion of sulphur over water; and sulphurous acid is said to be "constituted of 1 atom sulphur and 2 of oxygen in 100." We would inquire whether it is not so constituted in 10, 100, or 1000 parts? or whether its atomic constitution is altered by the quantity subjected to analysis, so that what is true of two portions of 50 parts each added together would not be true of 100 parts?

Nitric acid is said to be a compound of one atom of nitrogen and two of oxygen, instead of five of oxygen; but carbonic acid is one of the most extraordinary we have ever met with: "it is widely diffused through nature, being combined with chalk, limestone, gypsum, magnesia, &c." Of these four statements, one only is correct; chalk and limestone are not *combined* with carbonic acid, they consist of lime combined with it, and gypsum is neither combined with, nor contains carbonic acid; we need hardly say, that it consists of sulphuric acid and lime.

In speaking of nitrous oxide, it is stated to consist of "two atoms of nitrogen and one of oxygen." We suspect that our author has mistaken volumes for atoms; for this gas, although composed of two volumes of nitrogen and one volume of oxygen gas, is generally allowed to consist of only one atom of each.

It appears from Exp. 4, that our author does not know that nitric oxide and nitrous gas are different names for the same elastic fluid; for he says at p. 64, nitric oxide on coming into contact with atmospheric air receives a further portion of oxygen, and becomes nitrous gas.

We have neither time nor inclination to pursue our observations upon this work any further; and after what we have stated it would be superfluous to offer any additional opinion respecting it; but we cannot refrain from expressing our surprise, that a gentleman who must have distinguished himself in order to have acquired the degree of Master of Arts, should so far have forgotten what was due to his own reputation and to public utility, as to venture to write a book upon a subject, his ignorance of which *he* must have felt, and all conversant with chemistry must discover.—(P.)

Article XIII.

Proceedings of Philosophical Societies.

ROYAL SOCIETY.

May 27.—The reading of Mr. Abrahams' paper on Magnetism was concluded; and a paper was read, On the Direction of the Eyes in Portrait Painting; by W. H. Wollaston, MD. VPRS.

June 3.— —— Lemon, Esq. was admitted a Fellow of the Society; the name of Charles Macintosh, Esq. ordered to be inserted in its printed lists; and a paper was read, "On the Generation of Fishes; by J. L. Prevost, MD."

The Society then adjourned to June 17, in consequence of the ensuing holidays.

June 17.— —— Edgeworth, Esq. was admitted a Fellow of the Society, the name of Major Charles Hamilton Smith, ordered to be inserted in its printed lists; and the following papers were read, several of them in an abridged form.

On the Organs of Generation of the Axolotl, and of other Protei; by Sir E. Home, Bart. VPRS.

On the Effects of Temperature on Magnetism and on the diurnal Variation of the Needle; by S. H. Christie, Esq. MA.: communicated by the President.

On the Preservation of the Copper Sheathing of Ships, and on some Chemical Facts connected with it; by the President.

On the Application of Dœbereiner's new Discovery to Eudiometry; by William Henry, MD. FRS.

The Society then adjourned, over the long vacation, to meet again on the 18th of November next.

LINNEAN SOCIETY.

May 4.—M. G. St. Hilaire was elected a Foreign Member.

A notice from Mr. Wood was read respecting the Golden Oriole, *Oriolus Galbula*, shot on the 26th of April, flying in company with some Blackbirds, at Aldershot in Hampshire.

The reading was continued of Mr. Vigors's papers on the Natural Affinities of Birds; and of the Catalogue of Norfolk and Suffolk Birds, by the Rev. Messrs. Sheppard and Whitear.

May 24.—On this day, being the birth-day of Linnæus, the Anniversary of the Society was held at one o'clock, in conformity with the Charter, the Right Rev. the Lord Bishop of Carlisle, Vice President, in the Chair.

The following gentlemen were re-elected Officers:

Sir James Edward Smith, *President;*
Edward Forster, Esq. *Treasurer;*
Alexander Mac Leay, Esq. *Secretary;*
Mr. Richard Taylor, *Assistant Secretary.*

The following were elected to be of the Council for the ensuing year:—Edward Barnard, Esq.; H. T. Colebrooke, Esq.; Major-General T. Hardwicke; Daniel Moore, Esq.; and Philip B. Webb, Esq.

An extensive and interesting series of the various species of Rhubarb from Chelsea Garden was exhibited by Mr. Anderson.

The Anniversary Dinner of the Society took place at Freemasons' Tavern, and a considerable number of the Fellows, including many from distant parts of the kingdom, participated in the pleasure of this meeting, which was alloyed only by the absence, owing to indisposition, of their highly esteemed President, whose excellent qualities, great attainments, and invaluable labours for the promotion of science, have long endeared him to those who know him, and especially to the lovers of Natural History. The chair was filled on this occasion by the venerable Prelate, who from the first foundation of the Society has been one of its most zealous supporters.

June 1.—The reading of Mr. Vigors's paper was concluded; and that of Messrs. Sheppard and Whitear's Catalogue continued.

June 15.—The meeting of this evening, which was an extremely numerous one, was honoured by the presence of His Royal Highness the Prince of Saxe-Cobourg, and several other personages of distinction.

The reading was commenced of a paper, On the Structure of the Tunicata; by W. S. Mac Leay, Esq. MA. FLS. and the Society then adjourned, over the summer recess, to meet again on the 2d of November next.

ASTRONOMICAL SOCIETY.

May 14.—The whole of this sitting of the Society was occupied by the reading of the conclusion of Mr. Baily's paper On the Method of determining the Difference of Meridians, by the Culmination of the Moon; this paper having been commenced at the last meeting in April.

The author, after briefly alluding to the nautical methods of determining the longitude, including those by means of chronometers, adverted to five distinct astronomical methods which have been pursued, viz. 1st, By the eclipses of Jupiter's satellites. 2dly, By eclipses of the moon. 3dly, By eclipses of the sun. 4thly, By occultations of the fixed stars. And 5thly, By meridional transits of the moon. The first three of these, by reason of their infrequency and obvious sources of inaccuracy, are of very limited utility; while the fourth method is rendered uncertain from its involving a doubtful datum, *the compression* of the earth, as well as other difficulties which the author pointed out. He then proceeded to point out that the fifth method was greatly superior to any of the others, in which

opinion he was supported by the testimony of Dr. Maskelyne, Bernoulli, and many eminent astronomers who were quoted. Notwithstanding its high recommendations, this method has not been *successfully* adopted in practice, and has even led to some awkward anomalies, on account of its having been customary to take the moon's centre reduced to the meridian, and to compare it with the apparent places of stars passing the meridian about the same time in *any parallel of declination.*

The newly proposed method consists in merely observing with a transit instrument, the differences of right ascension between the *border* of the moon, and certain fixed stars previously agreed upon, restricting the observations to *such stars as differ very little in declination from the moon,* and denominated *moon culminating stars.* The attention of astronomers has been called to this method by M. Nicolai, of Manheim, in several numbers of Schumacher's *Nachrichten.* It is quite independent of the errors of the Lunar Tables (except so far as the moon's horary motion in AR is concerned). It does not involve the quantity of the earth's compression. It does not require a correct knowledge of the position of the star observed, nor does an error of a few seconds in the clock sensibly affect the result. Hence much trouble is avoided, many causes of error precluded; besides all which, the method is *universal.*

GEOLOGICAL SOCIETY.

May 21.—The reading of the paper "On the Geology of the Ponza Islands in the Mediterranean;" by George Poulett Scrope, Esq. MGS. was concluded.

The Ponza Islands lie off the coast of Italy, opposite Terracina and Gaieta. They consist of Ponza (anciently Pandataria), Palmarola, and some islets; Ventotiene and San Stefano connect them with Ischia. The harbour of Ponza is excellent. Dolomieu's Memoire sur les Isles Ponces excited curiosity, but is too general to satisfy it. These islands are composed of rocks, of the Trachytic series, and presenting fine sections along their coasts, enabled the author to clear up many doubts and errors which the mere investigations of inland localities have caused to be affixed to this formation.

The Isle of Ponza is long and very narrow, and is eroded by the sea into deep concavities. Harder masses left along its shores show that it once was broader, and protruding ledges mark its former connexion with Quannone and La Gabbia. Prismatic trachyte, variously coloured and disposed, forms the ossature of the island. It is constantly accompanied by, and alternates with, a semi-vitreous trachytic conglomerate, formed of minute pulverulent matter enclosing fragments of trachyte. The prismatic trachyte seems to have been forcibly injected through the conglomerate, and wherever it touches the latter

its earthy base is converted from two to thirty feet deep into a pitchstone-porphyry; sometimes it becomes a pearlstone, at others encloses a true obsidian. These rocks are connected with a silicious trachyte, resembling in appearance the silicious buhrstone of Paris. Resting on the semi-vitreous trachyte and forming the base of the Montagna della Guardia, is a rock 300 feet thick, which the author distinguishes mineralogically from common trachyte, and proposes to call greystone.

In Jannone the trachyte overlies a limestone, which Brocchi describes as transition limestone; at the point of contact this latter becomes dolomite. Having described the whole of this group, the author terminates his paper by connecting their geological structure with that of the neighbouring continent of Italy.

A paper was read, entitled, "Notes accompanying Specimens collected on a Journey through Part of Persia and the Russian Tartaries;" by James B. Fraser, Esq. MGS.

June 4.—A paper was read, entitled, "Description accompanying a Collection of Specimens made on a Journey through the Province of Khorosan in Persia;" by J. B. Fraser, Esq. MGS.

On quitting Teheran, the road passed by the roots of the chain of Elburz, through the pass Gurdunee, Sirdara to Semnoon and Shahrood, over gravelly hills, having to the south a salt desert, and appearances of salt on all sides; thence by Mey Omood, Abbassabad, Muzenoon, and Subzawar to Nishapore, about 40 miles west of which place are found the celebrated torquoise mines, which are worked along the sides and ridges of a narrow valley. The principal mine is called Abdool Rezakee. The calaïte is found pervading a soft yellow stone and a mouldering reddish rock, as also a rock of much firmer texture resembling quartz rock of a grey colour with reddish streaks, and containing specular iron. A conglomerate rock occurs in the vicinity. The mineral is found sometimes in veins, sometimes mammillated in fissures, and at other times irregularly dispersed through the rock. The author describes all the mines actually worked; they are the property of the crown, and were valued, when Mr. Fraser visited them, at the annual rent of 2000 tomauns of Khorosan, or about 3500*l.* sterling, and are farmed to the highest bidder. At Derroad, 25 miles from Nishapore, the primitive rocks of Elburz appeared similar to those seen in the lofty range between Ispahan and Cashan.

A paper was then read, entitled, "Geological Observations on the Sea Cliffs at Hastings, with some Remarks on the Beds immediately below the Chalk;" by T. Webster, Esq. Sec. GS.

This paper commenced with a geographical description of the cliffs on each side of the town of Hastings, from the White Rock on the west to the end of Fairlee cliff on the east, which

form a very instructive natural section of an elevated tract in Sussex, surrounded by, and coming out from under, the clay of the Wealds.

These cliffs consist of alternating beds of sandstone, shale, and clay, more or less charged with oxide of iron, and carbonized vegetable matter. The iron is most abundant in the lower part, where there are beds of two or three inches thick of rich argillaceous iron ore that were profitably worked before the fuel of this part of the country became scarce.

The middle beds of the cliff have much less iron, the greatest part consisting of very white friable sandstone. In the upper part of the series, there are many large blocks of a grey calciferous sandstone, the surfaces of which exhibit a mamillated structure: and this rock may be considered as a variety of the chaux carbonatée quartzifère of Haüy, having much analogy with the crystallized sandstone of Fontainebleau. The mamillated appearance is very well seen at the white rock, and has (though erroneously) been usually attributed to the action of the sea upon the fallen blocks.

The fossils, in the cliffs of Hastings, are not numerous; the shells being confined to two or three species of small bivalves, and a univalve resembling that in the Petworth marble. Thin layers of lignite are frequent, and fragments of a very singular silicified wood of the monocotyledon kind, the cavities of which are filled with minute transparent crystals of quartz.

Bones of large Saurian animals, and of birds, also occur, though rarely, together with scales of fish.

The author observed, that the grey calciferous rock has not hitherto been noticed in any part of the formations between the chalk and the Purbeck, except in this district; and from its not being co-extensive with the rest of the ferruginous sand series, and the want of continuity and correspondence in many of the beds, he took occasion to remark, that it may be frequently more correct to consider the subdivisions of some formations rather as *irregularly lenticular* than as *tabular* masses.

June 18.—A paper was read entitled "Notes on Part of the opposite Coasts of the English Channel, from Deal to Brighton, and from Calais to Treport;" by Wm. Henry Fitton, MD. MGS.

This paper was accompanied by a connected series of views or elevations of the coast, drawn by Mr. Webster, from the place where the chalk rises near Calais, to where, after being cut off near Blanc Nez, the chalk again appears upon the shore near Treport; and, on the English side, from the rise of the chalk near Deal, to where it sinks at Brighton. The author expresses his acknowledgments to the Baron Cuvier, through whom he obtained permission from the French authorities to

pass along the coast by sea, and experienced everywhere the greatest attention from the officers of the French customs. The paper briefly describes the leading geological features of the coast, reciting the partial descriptions already published, and referring, for an account of the cliffs near Hastings, to a memoir by Mr. Webster, read at the last meeting of the Geological Society; and for a detail of the beds which form the cliffs from Gris Nez to Equihen, to an account of the lower Boulonnois to be read at a future meeting. From Equihen to the mouth of the Somme, the coast is altogether occupied by dunes of sand, the sand hills being, in some places, especially in the vicinity of Etaples, more than 100 feet in height. These hills are, in general, somewhat crescent shaped, the back of the crescent being turned towards the prevailing wind, and the slope on the lee side much more rapid than the opposite one. The immediate base of the dunes seems to be peat, which is found both on the land side of them, and without, just on the verge of the sea, and in some places, below the level of high water: but no rocks have yet been discovered along the coast beneath the dunes. A list of heights obtained by the barometer is subjoined to this paper, and some detached sketches are annexed to it of interesting geological appearances on the French shore.

ARTICLE XIV.

SCIENTIFIC NOTICES.

CHEMISTRY.

1. *On the Nature of the free Acid ejected from the Human Stomach in Dyspepsia.*

OUR readers know from the notice of the proceedings of the Royal Society in the *Annals of Philosophy* (Feb. 1824), that in December last, Dr. Prout read a paper before that learned body, the object of which was to prove, that the acid usually found to exist in the stomach of animals, during the digestive process, is the muriatic. An acquaintance of mine, who occasionally suffers severely from dyspepsia, and was somewhat sceptical as to Dr. Prout's conclusions, lately requested me to examine the fluid ejected from his stomach during a violent dyspeptic paroxysm the day before, with the view of ascertaining the nature of the free acid it contained.

The fluid which had been thrown from the stomach in the morning, fasting, when filtered, was perfectly clear, and nearly colourless; it gave a decided red tint to litmus paper. I distilled about six ounces of it almost to dryness, at a gentle heat, receiving the product in three separate and nearly equal portions.

One-half of each portion was treated with nitrate of silver. The first had no effect on litmus paper, and scarcely gave the slightest cloud with the test. The second became slightly cloudy by the test, but was equally without any action on the blue paper. The third portion reddened the paper strongly, and produced an abundant dense cloud, when I dropped into it the nitrate of silver, and a pretty copious precipitate collected at the bottom of the tube. The remaining half of the third portion was evaporated by a gentle heat to about half a fluid drachm. The precipitate which a drop of it, placed on a slip of glass, occasioned with a drop of nitrate of silver, was insoluble in nitric acid, and perfectly soluble in ammonia. Another drop, similarly treated with muriate of barytes, gave no precipitate, nor cloud. The remainder was neutralized with pure ammonia, further evaporated, and poured on a slip of glass; when it afforded a multitude of well-defined crystals of muriate of ammonia.

The precipitate from the first half of the same portion by nitrate of silver, being collected, washed, and dried, fused on a slip of platina foil before the blowpipe into horn silver.

The presence of free muriatic acid in the ejected fluid, and consequently the accuracy of Dr. Prout's conclusions, seem to be fully confirmed by the preceding experiments. J. G. C.

2. *Pyroxylic and Pyroacetic Spirits.*

In a paper read before the Society of Physics and Natural History of Geneva, on the 16th Oct. 1823, MM. Macaire and Marcet have given a description and analysis of two fluids, analogous in many of their properties to alcohol, particularly in being capable, like it, of forming ethers when acted upon by acids. Pyroxylic spirit, the first of these, is obtained during the rectification of pyrolignous acid; the second was described long ago by M. Chenevix under the name of pyroacetic spirit, and may be prepared by subjecting the greater number of the acetates to distillation.

Pyroxylic spirit is colourless and transparent. Its smell is strong, pungent, and ethereal, and has a strong resemblance to that of ants. Its taste is strong, hot, and slightly pungent, leaving a distinct impression of the flavour of oil of peppermint. Its specific gravity, after having been distilled off dry muriate of lime, is 0·828. It boils at 150°. It reddens litmus paper very slightly; but this effect is probably produced by a minute residue of acetic acid; for when the spirit is distilled off litharge, a small portion of the oxide is rendered soluble in water. The dissolved salt is not precipitated by barytes, nor by nitrate of silver, and it contains no nitric acid: it appears, therefore, to be an acetate. When heated, the spirit burns with a fine blue flame, without leaving any residue. Alcohol dissolves it in

every proportion, and the addition of water renders the solution opalescent, and the spirit gradually ascends to the surface. Water alone converts the spirit into a semi-opaque fluid, resembling an emulsion, which persists for an indefinite length of time in this state, without a separation of the two fluids taking place, and without becoming transparent. It is equally insoluble in oil of turpentine. Camphor dissolves in it with great facility. Olive oil does not dissolve in it, either when cold or hot. Potash dissolves in it without producing any sensible alteration, except causing it to assume a yellowish tinge, and producing a slight elevation of temperature.

Pyroxylic spirit, when mixed with its volume of sulphuric acid, may be distilled over unaltered; but if thrice that quantity of acid be employed, it blackens, and is decomposed, and a small quantity of a gas is evolved, which is a mixture of hydruret of carbon and hydrogen. The gas contains no olefiant gas; for it burns with a feeble blue-coloured flame, and sustains no speedy diminution of volume when mixed with chlorine.

When distilled with its volume of nitric acid, there passes over an ethereal fluid, together with a considerable quantity of nitrous vapours. This new fluid has an agreeable odour, reddens litmus paper even after having been distilled off litharge, burns with a dull heavy flame, and dissolves in all proportions in water and alcohol, communicating to them a sweet taste, like that of sugar. It differs, therefore, in all its properties from nitric ether.

The spirit is not altered by being exposed to a current of nitrous gas; neither does it yield an ether when repeatedly distilled with its volume of muriatic acid.

A current of chlorine sent through a quantity of the spirit, at first imparts to it a deep-yellow colour; but after the process has gone on for a few minutes, the liquid suddenly becomes again colourless. By this treatment, its volume augments one-twelfth. The new fluid thus obtained is colourless and transparent, and smokes with ammonia. It has a peculiar and very pungent smell, and excites tears. Its taste is hot, leaving an impression exactly similar to that of horse-radish. After distillation off litharge, its specific gravity is 0·889. It burns with a blue flame and a white smoke, which gives thick vapours with ammonia. Water and alcohol dissolve it. It is precipitated by nitrate of silver; and it becomes more acid, and acquires a slight yellowish tinge by exposure for some time to the air and light; but by distillation off a little litharge, it may be restored to its original purity.

These two liquids, formed by the action of nitric acid and chlorine, appear, therefore, to be ethers, endowed with peculiar properties; and the mode in which the pyroxylic spirit is de-

composed by acids appears also to be completely analogous with the decomposition of alcohol, in the formation of those compounds to which the name of ether has been already appropriated.

Pyroacetic spirit is strikingly distinguished from the pyroxylic in many of its most important characters. Its specific gravity is inferior, being only 0·786. Its taste and smell are also different; and it burns with an intense white flame, very different from the blue flame of pyroxylic spirit. It is also completely soluble in oil of turpentine.

Sulphuric acid neither blackens it, nor renders it turbid, but communicates to it a fine orange-yellow colour; and the mixture continues transparent, even after the application of heat.

When distilled along with muriatic acid, a volatile fluid passes over having the odour of that acid; but this is completely removed by re-distilling it off potash.

A current of chlorine, sent through the pyroacetic spirit, communicates to it a slightly-yellowish shade, but without presenting the subsequent phenomenon of a sudden discoloration. The resulting fluid has a suffocating odour, somewhat similar to that of the chloro-pyroxylic ether, but stronger. After a few instants, it separates into two distinct fluids; the one, thick, heavy, oily, and transparent; the other, lighter, and slightly opalescent. The latter burns with a light flame, of a bluish colour, and leaves an abundant acid residue. It dissolves in water, and imparts to it a hot taste, followed by a sensation of sweetness; but it does yield a trace of the horse-radish flavour, which characterises the ether formed by chlorine and the pyroxylic spirit.

The oily fluid, after a few days, acquires a slight yellowish colour, and burns with a thick flame of a deep-green colour, emitting suffocating fumes, which contain abundance of muriatic acid. It is soluble in alcohol, but insoluble in water. When poured into the latter, it subsides to the bottom in separate drops.

Both of these *spirits* were analyzed, by volatilizing a known weight of them through red-hot oxide of copper. The pyroxylic spirit, decomposed in this way, was found to consist of

Carbon	44·53
Oxygen	46·31
Hydrogen	9·16
	100·00

Or very nearly, of 6 atoms of carbon, 4 of oxygen, and 7 of hydrogen.

The pyroacetic spirit was found to consist of

Carbon	55·30
Oxygen	36·50
Hydrogen	8·20
	100·00

Or very nearly, of 4 atoms of carbon, 2 of oxygen, and 3 of hydrogen.—(Bibliotheque Universelle, Oct. 1823.)

3. *Argillaceous Iron Ore.*

The analysis of this ore, given in the last number of the *Annals*, was incorrectly stated. The reader will perceive that the quantities of lime and carbonaceous matter, having been obtained from 200 grains of the ore, should have been divided by 2; and a small quantity of alumina separated from the precipitated oxide of iron being added, the composition will be nearly as follows, and as it will be found stated in Phillips's Mineralogy, p. 237, viz.

Protoxide of iron, with a trace of manganese	43·26
Carbonic acid	29·30
Silica and alumina	20·78
Carbonaceous matter	2·67
Lime	1·89
Moisture	1·00
Loss	1·10
	100·00 R. P.

4. *Aberthaw Limestone.*

This limestone, which is highly esteemed for the goodness of the lime which it yields, I have found to consist of

Carbonate of lime	86·17
Alumina	7·10
Silica	3·40
Carbonaceous matter	1·67
Moisture	1·00
Oxide of iron	0·66
	100·00 R. P.

MINERALOGY.

5. *Composition of Tourmaline.*

M. Gmelin, who has devoted a good deal of attention to the analysis of this mineral, deduces the following conclusions from his researches. All the tourmalines hitherto examined by him contain from two to six per cent. of boracic acid, which appears to be quite an essential ingredient. All of them contain also

two alkaline bases, which are a mixture in some cases of potash and soda, in others of potash and lithia. Magnesia also exists in most specimens, but does not appear to be so essential an ingredient as the preceding. Oxide of iron is sometimes present in a very large proportion; sometimes it is altogether wanting.

The rubellite, from Rozena, in Mahren, consists, according to his analysis, of

Boracic acid	5·744
Silica	42·127
Alumina	36·430
Oxide of manganese	6·320
Lime	1·200
Potash	2·405
Lithia	2·043
Volatile matter	1·313
	97·582

This mineral does not contain a trace of soda. The substance which Klaproth and Bucholz mistook for that alkali was in fact a mixture of boracic acid, potash, and lithia.

The schorl from Eibenstock, in Saxony, which was more recently analyzed by Klaproth, consists, according to Gmelin, of

Boracic acid	1·890
Silica	33·048
Alumina	38·235
Protoxide of iron	23·857
Soda with potash	3·175
Lime with traces of magnesia	0·857
	101·062

The tourmalines examined by him were six in number, and were all from different localities.—(Schweigger's Journal, vol. xxxviii. p. 514.)

6. *Petalite.*

Dr. Bigsby has discovered Petalite on the north shore of lake Ontario, on the beach in front of York, the capital of Upper Canada. It is a rolled mass weighing about a ton. The mineral has been examined by Dr. Troost; it occurs in crystaline masses, of a greyish white colour, with a tinge of green, and resembles some varieties of Tremolite, for which indeed it was first taken.—(See Jour. Acad. Nat. Sciences, No. 8, vol. 3.)

7. *New Localities of American Minerals.* By John W. Webster, MD. MGS. Lond.

Zircon and Green Felspar of Beverly (*Mass*). In a former

number of this Journal, page 390, we have noticed the discovery of green felspar at Beverly in this state. The specimens first found were met with in a stone wall; it was ascertained that the materials for the construction of the wall were taken from the common, or parade ground of Beverly, many years ago. Application was made to the proper authorities for permission to open the ground and make a thorough examination. The result of this undertaking has been highly satisfactory. The green felspar has been found in narrow veins traversing sienite, accompanied with crystals of zircon, and some other substances, the nature of which has not as yet been satisfactorily determined.

The crystals of zircon have an amber-brown colour, a resinous and oily lustre, with a fracture somewhat conchoidal and foliated. The cleavages, in some of the crystals, are tolerably distinct and indicate the octohedral primitive form. A few perfect octohedral crystals have been found.

The largest crystal in my possession, weighs 30 grains $\frac{4}{10}$ths, and its specific gravity is 4·06; it is a four-sided prism terminated by a four-sided pyramid; the terminal planes being set upon the lateral edges of the prism.

With the reflective goniometer I find the angle of inclination 130° 12′. The angles scratch rock crystal.

The hornblend and felspar which accompany these interesting substances, very much resemble those of the zircon sienite of Von Buch, with a specimen of which in my collection I have carefully compared it. The structure of this rock, and its geological connexions, are highly interesting. The following is Von Buch's description of the Norway zircon sienite. It is strongly distinguished from every porphyry by the magnificent, coarse granular, and sometimes large granular felspar, partly of a pearl-grey, and partly of a red colour, which always strongly characterises the blocks by its high degree of lustre. It is equally distinct from granite, sienite, or other similar granular stones, by the preponderance of the felspar. All the other ingredients seem to be sunk in this as a basis, and they often appear only occasionally; but hornblend is never wanting, and this hornblend is generally pretty characteristic and distinct; long black crystals, which possess a double foliated fracture by way of discrimination from mica—folia of mica also make their appearance but very rarely; and quartz shows itself in small grains, so as not to be altogether missed. It appears, in general, accidentally in the composition, and we search through whole hills without finding it again. Wherever the grains of the felspar meet, there remains almost always a small angular cavity into which crystals project. Among these, are the crystals of zircon, which give name to the rock. Epidote is associated with them in fine needles.

In the rock at Beverly, there is a great tendency of the component parts to assume regular crystalline forms, and a few perfect crystals of green felspar have been obtained.

Phosphate of Lime.—I have lately found a few pretty distinct crystals of phosphate of lime near the village of Stow, in this state. The crystals are disseminated in rolled masses of a coarse grained granite. They are portions of hexædral prisms, of a greenish-white colour. The fracture in the direction parallel to the base of the prism is distinctly foliated, and the powder phosphoresces on burning coals.

The same granite contains well defined crystals of beryl, and here and there a small crystal of tourmaline.

Andalusite.—This mineral I found in a rolled mass of white quartz, in small imperfect four-sided prisms, near Lancaster. The colour is a reddish-brown.

Spodumen.—A notice of this mineral has lately been published in the Journal of the Academy of Nat. Sci. of Philadelphia. I have visited the locality at Sterling, and find it very abundant. The principal rock in which it occurs is a compound of quartz, mica, and spodumen, weighing probably about thirty tons. It may be called spodumen rock.

Cleavelandite occurs in small quantity at Sterling.—(Boston Journ. of Philos. and the Arts, No. 6, May, 1824.)

Miscellaneous.

8. *On the Cause of the Rotatory Motion of Camphor in Water.*

(To the Editor of the *Annals of Philosophy.*)

SIR,

If your Cambridge correspondent E. A. (see *Annals* of last month) will look at page 51 of the first volume of Nicholson's Journal, 8vo. series, he will find that he is mistaken in supposing that no cause has been hitherto assigned for the rotatory motion of a particle of camphor when placed on the surface of water. Several eminent men, as he will there see, have turned their attention to this curious subject, amongst whom are Benedict Prevost, Venturi, and Caradori; and the results of their experiments will, I dare say, both interest and amuse your friend E. A. The paper alluded to is an abstract of M. B. Provost's inquiries on the subject, by M. Biot, who considers that we may infer from them, as an established fact, that "camphor is moved upon the surface of water by the effect of the emission of the particles which compose it; an emission that becomes perceptible to our senses by the smell which it produces, and by the repulsions which it exercises against small bodies floating upon the surface of water. As the effect resulting from these different impulses *does not pass through the centre of gravity of the piece of camphor*, this centre has a progressive motion, and the body revolves round it," &c. E. A. conceives the rotatory

motion to be wholly produced by the centre of gravity of the piece of camphor, and of the fluid displaced by it not being in the same vertical line. If that were so, an irregular piece of any substance capable of floating on water should, under the same circumstances, exhibit the same phenomena as a piece of camphor, which is not the case. Another, and co-operating cause must, therefore, be looked for; and there seems no reason to doubt that it is correctly assigned in M. Biot's abstract. Yours, F. B.

9. *Improvement in Clocks.*

The public papers, sometime since, contained information of an improvement in timekeepers, invented by Mr. Dyer, of this city. We hope hereafter to furnish our readers with a more particular account of this invention than is contained in the following brief notice:—

The most important feature in this improvement consists in the application of the *spiral teeth* to the wheel-work of clocks, and in this the pinion is reduced to a single tooth. By this happy idea, Mr. Dyer has greatly reduced the wheel-work necessary to a clock, and the friction is diminished in a still greater degree; as all who are acquainted with the spiral gearing are aware that the point of contact, between two wheels with spiral-teeth, always coincides with the line of centres. Mr. Dyer has also contrived a very ingenious method of suspending the pendulum, in place of the spring, or knife-edge suspension. This method is to hang the mass constituting the pendulum to a plane, the under surface of which rolls at every oscillation upon a fixed convex body. He proposes to give such a curve to the convex surface, that the pendulum, in vibrating, shall be accelerated at every moment of its descent by a force proportional to the arch between it and the lowest point; this condition being required to render the vibrations isochronal. Mr. Dyer has not yet demonstrated the curve necessary to obtain this result; but from the constant variation of the centre of oscillation, in a pendulum suspended in the above method, the cycloid is not the curve required. He is aware that his suspension cannot be executed with such accuracy as to render the vibrations perfectly isochronal; but he may undoubtedly obtain a near approximation to a curve which would render them so.—(Boston Journ. of Philosophy and the Arts, May, 1824.)

10. *Method of cleaning Gold Trinkets, and of preserving engraved Copper-plates.*

The method used by artists for cleaning gold trinkets is the application of a mixture of neutral salt, intended to disengage nitric acid, with the assistance of heat. Dr. Mac Culloch recommends instead to boil the trinkets in water of ammonia,

which dissolves the metallic copper of the alloy to a certain depth on the surface, so that after the operation the metal is in fact gilded, nothing but pure gold being visible. In this process the waste of gold, which is dissolved by the acid, in the process usually employed, is avoided.

Dr. Mac Culloch observes, "that it is an unaccountable omission of chemists not to have observed that metallic copper is soluble in ammonia. The solution takes place rapidly in the heat at which the water of ammonia boils."

Copper-plates are apt to be injured by laying by; a thin coat of oxide forms on the surface, which is rubbed off by the hand of the workman in the first inking, when the plate is again called into use; and by repetition of the formation of oxide, and its removal, the fine lines on the plate are soon injured, and ultimately obliterated. Dr. Mac Culloch recommends the application of common spirit varnish to the surface when the plate is laid by; it is easily applied, and can be removed when requisite by spirit of wine.—(Edinburgh Journal of Science.)

Article XV.

NEW SCIENTIFIC BOOKS.

PREPARING FOR PUBLICATION.

The Fourth Volume of the New Series of the Memoirs of the Manchester Literary and Philosophical Society.

A Compendium of Medical Theory and Practice, founded on Dr. Cullen's Nosology, which will be given as a Text Book. By D. Uwins, MD. in a duodecimo volume.

Muscologia Britannica: containing the Mosses of Great Britain and Ireland. By W. J. Hooker, FRS. ASL. &c. and T. Taylor, MD. MRIA. FLS. &c. 8vo. With Plates.

Mr. Swainson will speedily publish in an octavo volume, with six Plates of the most beautiful humming Birds of Mexico, the "Zoology of Mexico," illustrated by general Remarks and scientific Descriptions of the Animals collected by Mr. Bullock; to whose Travels the work is intended as an Appendix.

JUST PUBLISHED.

Wade's Observations on Fever. 8vo. 4*s.*

Woodford's Catalogue of Phænogamic Plants in Edinburgh. 12mo. 3*s.* 6*d.*

Harrison's Surgical Anatomy of the Arteries. Vol. I. 12mo. 5*s.*

Sandwith's Introduction to Anatomy and Physiology. 12mo. 9*s.*

The Butterfly-Collector's Vade-Mecum. 12mo. 5*s.*

Stevenson's Historical Sketch of the Progress of Discovery, Navigation, and Commerce, from the earliest Records to the beginning of the 19th Century. 8vo. 14*s.*

Otter's Life and Remains of the Rev. E. D. Clarke. 4to. *3l. 3s.*

The Encyclopædia Metropolitana, Part XII. containing, among other subjects, the completion of the article on Magnetism, Electromagnetism, and Electricity; and from CAP to CHI in the Miscellaneous Division.

ARTICLE XVI.

NEW PATENTS.

J. Crosby, Cottage-lane, City-road, for his improvement in the construction of lamps or lanterns, for the better protection of the light against the effects of wind or motion.—May 5.

J. Viney, Shanklin, Isle of Wight, for improvements in water-closets.—May 6.

W. Cleland, Leadenhall-street, for his improvement in the process of manufacturing sugar from cane juice, and in refining of sugar and other substances.—May 6.

J. T. Paul, Charing Cross, mechanist, for improvements in the methods of generating steam, and in the application of it to various useful purposes.—May 13.

J. Potter, Smedley, Lancashire, spinner and manufacturer, for certain improvements in looms.—May 13.

J. Perkins, Fleet-street, engineer, for his improved method of throwing shells and other projectiles.—May 15.

W. Church, Birmingham, for improvements in the apparatus used in casting iron and other metals.—May 15.

J. H. Ibbetson, Smith-street, Chelsea, for improvements in the manufacture of gas.—May 15.

L. W. Wright, Wellclose-square, engineer, for improvements in machinery for making pins.—May 15.

J. Luckcock, Round Cottage, Edgebaston, near Birmingham, for his improvement in the process of manufacturing iron.—May 15.

W. H. James, Cobourg-Place, Winson-green, near Birmingham, engineer, for his improved method of constructing steam-carriages.—May 15.

T. Parkin, Bache's-row, City-road, merchant, for improvements in machinery for printing.—May 15.

J. Dickinson, Nash Mill, Hertford, for his method of cutting cards by machinery, and also a process for applying paste or other adhesive matter to paper by means of machinery.—May 20.

J. Cook, Birmingham, gun-maker, for improvements in the method of making and constructing locks for guns, pistols, and other fire-arms.—May 20.

T. Marsh, Charlotte-street, Portland-place, saddler and harness-maker, for an improvement in the making of saddles.—May 20.

J. Viney, Shanklin, Isle of Wight, for his method of supplying water or fluids for domestic or other purposes in a manner more extensively and economically than has hitherto been usually practised.—May 22.

B. Black, South Molton-street, Hanover-square, lamp manufacturer, for his improvement on carriage-lamps.—May 25.

Article XVII.

METEOROLOGICAL TABLE.

1824.	Wind.	Barometer. Max.	Barometer. Min.	Thermometer. Max.	Thermometer. Min.	Evap.	Rain.
5th Mon.							
May 1	S W	30·05	30·00	66	51	—	11
2	N	30·00	29·71	61	41	—	24
3	N W	29·77	29·69	47	40	—	28
4	N W	29·98	29·77	52	39	—	—
5	S W	30·01	29·98	62	47	—	08
6	S W	30·01	29·99	66	42	—	05
7	N	30·27	30·01	68	43	—	
8	N	30·40	30·27	68	48	—	
9	S E	30·40	30·13	62	39	—	
10	N E	30·13	30·09	69	42	·84	
11	E	30·09	30·03	54	44	—	—
12	N E	30·03	29·99	53	40	—	17
13	N E	29·99	29·70	50	42	—	48
14	N E	29·70	29·67	48	43	—	59
15	N E	29·91	29·65	46	42	—	1·67
16	N	30·05	29·91	56	37	—	—
17	N W	30·06	30·05	55	44	—	
18	N W	30·06	29·93	55	37	—	—
19	N W	29·93	29·87	56	40	—	
20	N W	30·00	29·87	57	29	—	
21	E	30·07	30·00	61	32	—	
22	N E	30·07	30·03	56	32	—	—
23	N W	30·03	30·02	61	42	—	—
24	N	30·26	30·02	58	34	·94	11
25	N E	30·49	30·26	62	48	—	
26	N	30·64	30·49	72	46	—	
27	N W	30·64	30·61	70	40	—	
28	S W	30·61	30·40	76	41	—	
29	N E	30·40	29·98	69	51	—	
30	E	29·99	29·98	68	48	—	01
31	S W	30·23	29·99	70	48	·82	
		30·64	29·65	76	29	2·60	3·79

The observations in each line of the table apply to a period of twenty-four hours, beginning at 9 A. M. on the day indicated in the first column. A dash denotes that the result is included in the next following observation.

REMARKS.

Fifth Month.—1. Fine. 2, 3. Rainy. 4, 5. Showery. 6—8. Fine. 9. Fine: a solar halo, coloured, a little before sunset. 10. Fine: a lunar halo of the largest diameter. 11. Overcast: cold wind: a lunar halo at night, with a bright spot on each side, at the same height as the moon. 12. Showers. 13. Rainy. 14. Rainy. 15. Rain, without ceasing, all day. 16. Cloudy. In consequence of the heavy rains of the last four days, amounting on the whole to 2·91 inches, a flood was naturally expected this morning; and towards evening the waters rose suddenly in the sea, and passing over all the banks of the level, soon filled the marshes, and in the course of the night rose to an unprecedented height, being 2½ inches higher than in the flood of 1809. The houses in the marshes south of the road were filled nearly to the chamber floors, and some of the inmates removed with great difficulty: the flood remained stationary for nearly 24 hours. On the 17th in the afternoon, it began very gradually to subside, and on the 18th, in the morning, was much abated; the marshes still presenting the appearance of a bed, the tops of the trees appearing in places only. 17—19. Cloudy and fine. 20—23. Fine. 24. Morning showery. 25—29. Fine. 30. Fine: a slight shower in the morning. 31. Cloudy and fine.

RESULTS.

Winds: N, 6; NE, 8; E, 3; SE, 1; SW, 5; NW, 8.

Barometer: Mean height

For the month	30·070 inches.
For the lunar period, ending the 20th	29·976
For 14 days, ending the 8th (moon north)	29·972
For 14 days, ending the 22d (moon south)	29·978

Thermometer: Mean height

For the month	51·064°
For the lunar period	51·666
For 31 days, the sun in Taurus	51·693

Evaporation	2·60 in.
Rain	3·79

Laboratory, Stratford, Sixth Month, 24, 1824. R. HOWARD.

ANNALS

OF

PHILOSOPHY.

AUGUST, 1824.

Article I.

Remarks on Solar Light and Heat. By Baden Powell, MA. of Oriel College, Oxford, and FRS.

(*Continued from* vol. vii. p. 406.)

(27.) In the conclusion of a former paper I alluded to some further experiments which were to follow, relative to the question of the proportion obtaining between the heating and illuminating effects of the solar rays. The method of experimenting alluded to is one which I have not been able to apply to any extensive series of different intensities. It consists in comparing the effect produced on a blackened thermometer by the focal light of different lenses, with the relative calculated intensities of the rays in those foci. Thus we may ascertain whether at these high intensities the same proportion is maintained. Without proof we cannot assume that it is; and a very few comparisons may be sufficient to show, whether the proportion is nearly preserved, or whether there be any considerable deviation from it.

(28.) When thermometers are exposed to the action of radiant matter there are several considerations to be attended to in comparing their observed risings; and it will be convenient in the first instance to bring these considerations into one point of view.

A thermometer exposed to radiant matter absorbs heat only on one-half of its surface, while the other half is radiating again its acquired heat, and the observed effect depends upon the equilibrium which obtains between them. In particular cases only part of one surface may be exposed to heat: the difference between such part and the whole surface, together with the absorbing and radiating powers of the surface, must, therefore, be taken into consideration, as also the rate of communication of heat dependent on the mass.

Let the portion of the surface of the bulb exposed to radiant matter $= a$
Diameter of the bulb. $= d$
Its surface $= s$
The observed rise in a given time $= r$
The power of the coating for absorbing heat (of whatever kind) $= p$
And for radiating it $= k$
The intensity of heating power $= h$

The general formula easily deduced on the above considerations will be,

$$r = h \cdot \frac{a \cdot p \cdot d^2}{d^3 \cdot (s - a)\, k}$$

$$= h \frac{a \cdot p}{d\,(s - a)\, k}$$

$$\therefore h \frac{p}{k} = r \frac{d \cdot (s - a)}{a}.$$

When the whole bulb is exposed,

$$s - a = \frac{s}{2},$$

$$\therefore a = \frac{s}{2} \text{ and } \frac{s - a}{a} = 1,$$

$$\text{And } \therefore \frac{h p}{k} = r d.$$

Comparing two different cases,

$$\frac{h p k_1}{h_1 p_1 k} = \frac{r \cdot d \cdot a_1 (s - a)}{r_1 \cdot d_1 \cdot a (s_1 - a_1)} \quad \ldots\ldots\ldots\ldots (A)$$

If $h = h_1$ we thus obtain the value of $\frac{p k_1}{p_1 k}$.

If the bulbs are equal, this $= \frac{r \cdot a_1 (s - a)}{r_1 \cdot a (s - a_1)}$ (B)

And if the coating be the same, it $= \frac{h}{h_1}$, and if $h = h_1$ it $= 1$.

When the whole bulb is exposed, we have

$$\frac{h p k_1}{h_1 p_1 k} = \frac{r \cdot d}{r_1 \cdot d_1} \quad \ldots\ldots\ldots\ldots\ldots\ldots (C)$$

If in this last case the thermometers be exposed to simple radiant heat, assuming the universality of the law, that the absorptive is proportional to the radiating power of a surface, we shall have

$$p = k, \text{ and } p_1 = k_1$$

And if $h = h_1$ then $\frac{r d}{r_1 d_1} = 1$, or $\frac{r}{r_1} = \frac{d_1}{d}$.

Or hence we might derive a neat and simple method of verifying that law.

The relative values of p and k as compared with a surface of glass in particular cases, may be obtained by coating only half

the surface of the bulb, and exposing either the plain or coated side to the same intensity of heat. The ratio $\frac{k}{k_1}$ may be obtained by heating two bulbs completely coated to the same point, and observing their rates of cooling.

The case (C) is the same as that investigated in the Phil. Trans. 1800, No. 19, note, p. 447.

(29.) *Comparison of the Focal Effect of Two Lenses on a Thermometer coated with Indian Ink.*

	Focus.			
Min.	Lens 1.		Lens 2.	
		Diff.		Diff.
0	18	—	18	—
1	50	32·0	27	11·0
0	15	—	16	—
1	45	30·0	26	10·0
0	19	—	16	—
1	51	32·0	26	10·0
	Mean	31·3		10·3

In order to proceed to this comparison, we must first observe, that when in the formula we take $a \cdot d^2$, it is on the supposition that *parallel* rays impinge on a spherical surface. With the focus this is not the case, and from the convergence of the rays, as well as from their greater intensity at the outer edge, we may in this case assume, without fear of error, that a = the area of the section of the rays impinging, and thus apply the formula. Thus we have the following data:

From the above experiments, $r_1 = 10$, $r = 31$: it is also evident, that $p = p_1$ and $k = k_1$. By measurement, the diameters of the focal disks were:

Lens 1.	Lens 2.
0·25 inch	0·16 inch
$\therefore$ the areas 0·049 $= a$	0·021 $= a_1$

$d = 0{\cdot}45 \therefore s = {\cdot}636.$

Hence $s - a_1 = {\cdot}615$ $s - a = {\cdot}587,$

and we have to apply the case of the formula (B)

$$\therefore \frac{k}{k_1} = \frac{31}{10} = \frac{587}{615} \times \frac{21}{49} = \frac{160}{301} = \frac{1}{1{\cdot}88} \text{ nearly.}$$

(30.) In order to calculate the respective intensities of light, or number of rays collected in the focus of each lens, we may easily proceed by the well-known theorem,

Let d = diameter of aperture,
f = focal length of lens, No. 1.
And d', f', those of lens, No. 2.

I, and I', = the respective intensities of the rays collected in the sun's image, or focal luminous disk.

Then we have

$$\frac{I}{I'} = \frac{d^2 . f'^2}{d'^2 . f^2}$$

By measurement I found

In Lens, No. 1, $d = 3{\cdot}25$ in. $\therefore d^2 = 10{\cdot}56$,
$f = 7{\cdot}5$ $\therefore f^2 = 56{\cdot}25$,
In Lens, No. 2, $d' = 1{\cdot}75$ in. $\therefore d'^2 = 3{\cdot}06$,
$f' = 3$ $\therefore f'^2 = 9$.

Hence $\frac{I}{I'} = \frac{10{\cdot}56 \times 9}{3{\cdot}06 \times 56{\cdot}25} = \frac{95{\cdot}04}{172{\cdot}12} = \frac{1}{1{\cdot}81}$ nearly.

If we admit the validity of certain experiments which seem to prove the existence of an exterior heat surrounding the luminous cone of rays, this would affect the bulb in each case by a small quantity in addition to the direct effect of the light. But since the total effect has been shown to be very closely in proportion to the intensity of focal light, it would follow that this exterior heat must be in extent, or in energy, exactly in the same proportion, supposing its absolute value sufficiently great to produce a perceptible effect.

These experiments prove for the two particular intensities under examination, that the proportion of heating to illuminating intensity is closely maintained. It might be satisfactory to extend the comparison with lenses of other powers, qualities, &c. but as the above result is not of a nature which requires the admission of any new principles, and agrees with what we should be prepared to expect, I conceive it unnecessary at present to carry the examination any further.

(31.) With a similar object in view in some subsequent experiments, I employed such a difference of intensity as is afforded by two sections of the luminous cone formed by a lens, one being made near the lens, and the other near the focus.

In two such positions, one, at $\frac{1}{4}$ inch from the lens, the other near the focal point, or at about seven inches distance, the thermometer, blackened as before, was placed successively. The rise in 30 seconds was (mean of three trials),

At $\frac{1}{4}$ inch from lens $2^\circ = r$
Near focus. $40 = r_1$

To obtain the proportions of light in the two cases, I measured the diameter of the luminous circle formed by the larger section when the rays were intercepted by a plane at the distance of one-quarter of an inch below the lens. The diameter was very nearly 2·8 inches = d, whose square = 7·84; the diameter of

the bulb (as before) = 0·45 inch; the diameter of the section near the focus = d_1 = 0·3 inch; its square ·09.

In order to obtain the true ratio of the heating effects, we have to apply the case of the formula (B). By experiment, we have $\frac{r}{r_1} = \frac{1}{20}$: by measurement a_1 = ·0706.

And s = 6361 $\therefore s - a_1$ = ·5655.

Here also the case of the formula (C) applies, and we have $\frac{s-a}{a} = 2$; thus on the whole since $p = p_1$, and $k = k_1$

$$\frac{h}{h_1} = \left(\frac{2 \times \cdot 0706}{\cdot 5655} = \right) \frac{1}{4} \cdot \frac{1}{20} = \frac{1}{80}.$$

Hence also we have for the intensities of light in the two cases,

$$\frac{I}{I} = \frac{d_1^2}{d^2} = \frac{\cdot 09}{7 \cdot 84} = \frac{1}{87}.$$

In obtaining this ratio, however, there are evidently several sources of error; the loss of many rays before they arrive at the focus; the less intensity towards the central part of the cone (where the thermometer was placed), on these, and, perhaps, other grounds, it would be necessary to reduce the ratio obtained.

The former ratio (as also in other instances) is subject to some uncertainty, owing to the difficulty of observing accurately the rise of the thermometer under the strong impression of focal light; but upon the whole it is evident that here also an equality of ratio may be inferred as nearly as the nature of the operations will allow.

If there be an exterior heat about the focus, this should affect the above ratio; but since the proportion obtaining is very close, we may infer that the ratio of the intensities of light is really greater than that of the heating effects, but that the proportion is preserved by the sum of the heating effect of the focal light, together with the exterior heat. The above experiment cannot be considered sufficient to enable us to determine such a point, but I hope shortly to be able to give it a more complete examination.

(32.) In like manner we might proceed to compare the effects of the rays in their natural diffuse state, and when brought to a focus, if we had any tolerably accurate method of allowing for the quantity of light lost in passing through the lens, and in not converging accurately to the focus. The former datum might, perhaps, be supplied from Sir W. Herschel's determination (Phil. Trans. 1800), and the latter we might probably estimate by successively diminishing the aperture till the focal effect on the thermometer becomes diminished. The least aperture with which it continues undiminished, compared with the whole, would give nearly the proportion of rays brought to the focus.

(33.) In the preceding instances we have compared the pro-

portion of heating to illuminating effect in respect to light of different intensities. Another point of inquiry which appeared to me not uninteresting in relation to the same subject, is the similar question with respect to the proportions of heating effect developed by differences of light in respect of the light or dark colour of surfaces: and whether the same proportion which is observed in the heat produced on a black and on a white surface at ordinary intensities is preserved or not at higher degrees of concentration in the rays.

The heating effect of light is commonly said to be produced by the absorption of the rays, and is supposed to be proportional to the degree of that absorption. In order to advance towards a clear and systematic knowledge of the subject, it would be necessary that this should be proved, especially as we may thus become better acquainted with the nature of the heating effect developed or excited when light impinges on surfaces of different colour.

We have not, perhaps, any very precise idea as to the mode by which light exerts its heating power; nor can it be assumed that any exact proportion is followed by the absorbing power of surfaces, with the degree of heat produced. It is obvious that a variety of laws may be supposed to obtain.

The heating effect may not be in proportion to the quantity of light absorbed, or the quantity absorbed may not be in the proportion of that impinging, or both may take place jointly.

It, therefore, becomes necessary to inquire, first, whether on the black and the white surface the heating effects are in the same ratio as that of the *intensities* of light acting upon them; secondly, whether, in the case of the diffuse and of the concentrated rays, the black and white surfaces receive heating effects in the same ratio as that of the light which acts upon them in respect to their colour.

(34.) In order to follow up these inquiries, the following experiments were tried.

I employed two thermometers, one having its bulb coated with Indian ink, and the other with a thin paste of chalk and water. They were both fixed on one mounting, so that it might be safely assumed, that they were both equally exposed to the heating power to which they were subjected; and the bulbs were completely free from any contact with the mounting, more than one-eighth of an inch intervening on all sides.

By measurement, the following data were obtained:

Diameters of the bulbs.....	$d = \cdot 55$ in.	$d_1 = \cdot 45$
Whence the surfaces	$s = \cdot 950$	$s_1 = \cdot 636$
Diameter of the focal disk $= \cdot 25$, whence its area $a = \cdot 049$..,	$-\cdot 049$	$-\cdot 049$
	$\cdot 901 = s - a$	$\cdot 587 = s_1 - a$

And $a = a_1$

Substituting these values in the formula (A), we have, with the focus, the correction

$$\frac{d}{d_1}\cdot\frac{s-a}{s_1-a}=\frac{55}{45}\times\frac{901}{587}=\frac{1000}{532}\text{ . or }\frac{187}{100}.$$

With the diffuse rays, it becomes (C)

$$\frac{d}{d_1}=\frac{1000}{818}\text{ . or }\frac{122}{100}.$$

(35.) To compare the heating effects, the following sets of experiments were made:

Focus. Rise in 30 seconds.		Diffuse rays. Rise in 2 minutes.	
Th. A. White.	Th. B. Black.	Th. A. White.	Th. B. Black.
12	47	2·5	6·5
11	44	2	5·5
11	42	1	2·5
11	45	2·75	7
12	48	1·25	3
10·5	40	3	7
12	47		
12	47		

The ratios of these respective quantities in each case agree very nearly among themselves. We may obtain the mean ratio in each case by taking

Mean 11·4	45	2·08	5·6
Hence $\frac{r}{r_1}=\frac{1}{3\cdot9}$		$\frac{r}{r_1}=\frac{1}{2\cdot6}$	

Hence, since in each case, $h=h_1$ we obtain

In the one case, $\frac{p\,k_1}{p_1\,k}=\frac{1}{3\cdot9}\times\frac{1000}{532}=\frac{1}{2\cdot07}$,

And in the other, $\frac{p\,k_1}{p_1\,k}=\frac{1}{2\cdot6}\times\frac{1000}{818}=\frac{1}{2\cdot12}$.

(36.) Another set of experiments in which the coatings were mutually changed, were as follows:

Focus. Rise in 30 seconds.		Diffuse rays. Rise in 2 minutes.	
Th. A. Black.	Th. B. White.	Th. A. Black.	Th. B. White.
25	18	5·25	2
28	16	4·25	2
27	16	7·5	3
28	17	5	1·75
28	17	6	2·75
26·5	17	7·75	3·5
Mean 6 ex. 27	16·8	5·95	2·5
$\frac{r}{r_1}=\frac{1}{1\cdot6}$		$\frac{r}{r_1}=\frac{1}{2\cdot3}$	
$\frac{p\,k_1}{p_1\,k}=\frac{1}{1\cdot6}\times\frac{100}{187}=\frac{1}{2\cdot9}$		$\frac{p\,k_1}{p_1\,k}=\frac{1}{2\cdot3}\times\frac{100}{122}=\frac{1}{2\cdot8}$	

The former set of experiments gives the ratio in the focus somewhat less than in the diffuse rays, the latter somewhat greater. We may, therefore, fairly infer, that the ratios are very nearly equal in the two cases. The means are $\frac{1}{2{\cdot}48}$ and $\frac{1}{2{\cdot}46}$.

The small difference between these two sets of experiments must be attributed to the impossibility of laying on the coatings in the second instance so as to be sure that they are of precisely the same thickness, roughness, &c. as in the first; but the disagreement is so small as to show that such an equality was as nearly attained as perhaps was possible.

(37.) Being in possession of these two sets of experiments, we might have deduced the result without any reference to the formula. Proceeding by this method, therefore, we may ascertain the accuracy of the data, and thus also tend to show how far the other investigations here made are to be relied on. It will be evident that we have in these two sets, with the foci,

$$\frac{p\,k_1}{p_1\,k} = \frac{1}{3{\cdot}9} \times \frac{m}{n} \text{ 1st set.}$$

$$\text{And } \frac{p\,k_1}{p_1\,k} = \frac{1}{1{\cdot}6} \times \frac{n}{m} \text{ 2d set.}$$

$$\text{Whence } \frac{(p\,k_1)^2}{(p_1\,k)^2} = \frac{1}{3{\cdot}9 \times 1{\cdot}6} \times \frac{1}{6{\cdot}24},$$

$$\text{And } \therefore \frac{p\,k_1}{p_1\,k} = \frac{1}{2{\cdot}5} \text{ nearly.}$$

In the same way with the diffuse rays,

$$\frac{p\,k_1}{p_1\,k} = \frac{1}{2{\cdot}6} \times \frac{m'}{n'} \text{ 1st set.}$$

$$\text{And } \frac{p\,k_1}{p_1\,k} = \frac{1}{2{\cdot}3} \times \frac{n'}{m'} \text{ 2d set.}$$

$$\text{Hence, as before, } \frac{(p\,k_1)^2}{(p_1\,k)^2} = \frac{1}{5{\cdot}98},$$

$$\text{And } \therefore \frac{p\,k_1}{p_1\,k} = \frac{1}{2{\cdot}4} \text{ nearly,}$$

results which agree very closely with those otherwise obtained.

(38.) In order to separate from this result the value of $\frac{p}{p_1}$, I ascertained $\frac{k}{k_1}$ by independent experiment: heating the two thermometers to the same point, and then observing their rates of cooling, as follows:

	Th. A. White.		Th. B. Black.	
		Diff.		Diff.
Heated to	23		23	
Cooled in 2 minutes to	21·25	1·75	21	2
	28		28	
	25	3	24·75	3·25
	24		24	
	21·75	2·25	21·5	2·5
	23		23	
	20	3	19·75	3·25
	Mean	2·5		2·75

Hence $\frac{r}{r_1} = \frac{1}{1\cdot1}$.

Hence on the same principles as before (r and r_1 being now the respective rates of cooling), we have

$\frac{k}{k_1} = \frac{r\,d}{r_1\,d_1}$; and since by experiment

$\frac{r}{r_1} = \frac{10}{11}$ and $\frac{d}{d_1} = \frac{1000}{818}$,

We obtain $\frac{k}{k_1} = \frac{100}{89}$,

Whence taking $\frac{p\,k_1}{p_1\,k} = \frac{1}{2\cdot5}$, we get

$\frac{p}{p_1} = \frac{1}{2\cdot2}$.

Here again if when the focus was thrown on the bulb, it was encompassed by a sort of penumbra of a heating effect, this being of the same nature as simple heat, acted on the black and white surfaces in the inverse ratio of the diameters, and, therefore, tended by the addition of very small quantities in that ratio to each of the terms of the ratio, to increase it, though probably the effect was altogether too small to be perceptible.

(39.) We now proceed to compare these heating effects with the intensities of light absorbed by the black and white surfaces.

In the first instance, I attempted roughly to estimate the proportions of light *reflected*, and thence reciprocally *absorbed* by black and white surfaces in the following manner: On a red ground were fixed a black and a white small circular disk; also two similar disks on a blue ground. Remaining at a fixed distance from them, having first darkened the room completely, I increased by degrees the aperture of a sliding shutter, till first the white disk, and then the black, became visible. This was repeated several times, and the mean ratio of the size of the

aperture necessary for the two effects would give the proportion of light reflected by the disks.

In the same way also I tried the distances from the eye at which the disks became invisible in a room partially darkened. Such trials, however, can never be susceptible of any accuracy from the difficulty of saying precisely when the object is visible or not. I, therefore, conceive it unnecessary to detail them further than to mention, that the results uniformly gave a ratio not very different from that above given, as the ratio of the heating effects produced respectively by the proportions of light which we suppose absorbed by the surfaces.

It became necessary to seek for some other method of ascertaining this point; and in this I succeeded as follows:

(40.) Assuming that within ordinary limits, the heating effect is precisely as the number of rays impinging, we may proceed to a simple and, perhaps, sufficiently accurate method of estimating the relative proportions of light *absorbed* by the black and white surfaces employed on the thermometers from observing the quantities *reflected*. These data I obtained by placing the photometer in the sun's light having the bulb protected by a small screen from the direct rays, and, therefore, affected only by the light reflected from a surface of paper, painted in one instance with Indian ink, and in another with chalk; and fixed in contact with the outside of the glass case of the instrument, on the side opposite the sun, and extending round two-thirds the circumference of the cylinder.

The following are the results of a set of experiments conducted in this way:

Exp.	Rise in 1 minute by light reflected from	
	Black surface.	White surface.
1	6	14
2	6	12
3	6	13
4	7	14
5	6	14
To obtain the mean ratio	6·2	13·4
Or	1	2·1 nearly

Hence we may take the proportions of light *absorbed* by the two surfaces in the inverse of this ratio.

This ratio may, however, possibly be rather too small, from the circumstance that a small portion of light would be reflected upon the bulb from the inner surface of the glass, which would be the same in both cases.

If on this consideration we take it $= \frac{1}{2 \cdot 2}$, this ratio, it will

be evident, agrees as nearly as we can expect with that before obtained for the heating effects developed upon or by the black and white surfaces under examination; and which was shown to be nearly the same, whether the light was in its ordinary intensity, or at a high degree of concentration.

(41.) We have thus established that with considerable differences in the intensity of light acting, the *heating* effects on a *black* and a *white* surface maintain the same ratio very closely.

It has also been shown that on the *same* surface, with different *intensities* of light, the heating effect is proportional to the intensity of light.

At one intensity it is shown that the *heating* effects on the black and white surfaces are proportional to the quantities of *light* respectively *absorbed* by them.

Hence the *heating* effect is proportional to the light *absorbed* by the surface in respect to its colour, at all *intensities*.

Hence also the light *absorbed* at different intensities is proportional to that *impinging* on the same surface.

These conclusions contain, perhaps, no information absolutely new; but in establishing experimentally what seems hitherto to have been only taken for granted on loose grounds, I conceive we may best prepare the way for investigating the nature of the heating power of light, and for examining whether it be analogous to any other phœnomena. One step appears to me to be gained in having, as I think, clearly shown the exact proportionality in the heating effect to the quantity of light acting, and shown to be actually absorbed by the surfaces. These experiments also confirm (if further proof be wanting) the conclusion that the sun's heating effect is of a simple nature.

(42.) It may not be altogether superfluous here to remark, the dependance of the results in the former portions of these inquiries (see (18) of the paper in the *Annals* for June), upon the considerations laid down in the present paper (28). It will be thence evident that without knowing any thing of the relative powers of the surfaces for absorbing simple heat or radiating it again, if any such heat were intercepted by the glass, the effect on removing it would have been a diminution of ratio by the addition of *equal* quantities to its terms; supposing that the heat were *instantaneously* communicated from the front to the back of the bulb. If this were not the case, but a certain time were required for the effect to be produced, it would at the first moment be an addition of quantities in the ratio of the absorptive powers of the surfaces for simple heat: this, in the present case, would be a ratio of "greater inequality," and as appears from (38) nearly $= \frac{100}{89}$.

Again, with respect to the subsequent experiment (*Annals*,

June, (19), (20), it is equally obvious that the same distinction must be attended to; but if the lower bulb were only coated on the *half* of its surface exposed to the sun, the effect (if any were produced) would be greater, since here the ratio of "greater inequality" must operate. In this way I have repeated the experiment with a half coating of chalk, but with results so precisely the same as before, that no diminution was perceptible. In order to try the effect with a coating of still greater absorptive power, I repeated the experiment with a bulb half coated with white silk pasted on; the other being entirely painted with Indian ink. No diminution took place, as will be evident from the following results. The instrument was of a larger construction, and not graduated by Prof. Leslie's scale.

Large differential thermometer. Bulbs, Indian ink; and white silk on half. Graduation *from* white.

Glass over white bulb, 3 inches.			Both exposed.	
14°			14°	
15°			15°	
12°	11°		12°	13°
16°	15·5°		15°	14°
16°			16°	

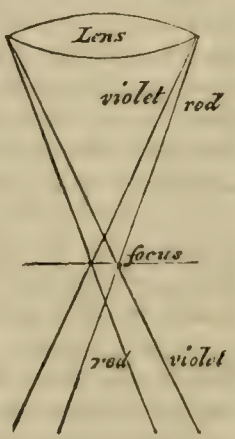
(43.) The question above alluded to (31, &c.) as to the existence and magnitude of a heating effect exterior to the cone of light formed by a lens, is one of the greatest curiosity and interest, especially as connected with what appears to be the analogous effect in the case of the prismatic spectrum. In a supplement to a paper on the latter subject, communicated some months since, and now before the Royal Society, I recorded a few imperfect experiments, in which it appeared to me that this phenomenon was clearly perceptible with a lens of about three inches aperture, and 7·5 focal length, by means of the differential thermometer; and I have since repeatedly observed the same thing, though from the smallness of the effects observed I am inclined to suppose that they could hardly have interfered in any sensible degree with the experiments described in the present paper. From the very small intensity of the effect in question, I have experienced great difficulty in applying both the test of its transmissibility through glass, and that of its relation to surfaces, so as to come to any decisive conclusion. I hope shortly to be able to bring forward some investigation of these points. Meanwhile, as connected with the subject of the present paper, I may be permitted to give the results of a few experiments, which clearly establish the existence, and convey an idea of the quantity of this effect; and which were made with a different instrument, and under different circumstances, from the few just alluded to.

(44.) Observations of the heat exterior to the cone of light formed by a lens. Aperture, 3·25 inches ; focal length, 7·5. Bulb of photometer coated with Indian ink, in glass case.

Distance without the rays.	Distance from lens.	Indication of photometer.	
		Exper. 1.	Exper. 2.
½ inch.	7·5 inch (at focus)	17°	16°
	6	12°	12° 11°
	4	12° 10°	
	2	9° 8° 7°	9° 8°
	Close under lens.	8° 7°	7°
½ inch.	7·5 inch (lens covered)	5° 4°	
1·25 inch (under the furthest part of the shadow).	7·5 (lens open)	4°	

The two last observations show how much of the effect is to be attributed to reflected light.

(45.) The experiment of Sir W. Herschel, from which a maximum heating effect further from the lens than the focus of greatest light is inferred, will be found in the Phil. Trans. 1800, No. 15, Ex. 23. It there appears that sealing-wax was scorched in the same time in the focus, and at half an inch further from the lens ; whilst at half an inch nearer, no effect was produced in double the time. It can, perhaps, scarcely be inferred, that this effect is due to the same cause as that which operates outside of the luminous cone ; since it is obvious, that beyond the focus the light again diverges, and we cannot with certainty distinguish the effects due to light under the peculiar modifications to which it may there be subjected, from those which may arise from some peculiar development of heat in the same position. The mere inspection of the adjoining diagram will illustrate the directions which the differently coloured rays, separated by the dispersive power of the lens, are made to assume ; and with their different combinations it is highly probable that very different heating effects are produced. This is a topic of great interest, and one which, if more thoroughly examined, seems likely to lead to a more complete acquaintance than we at present possess with the nature of the heating effects developed both by the rays of light themselves, and at short distances from them.



Article II.

On the Corrosion of Copper Sheeting by Sea Water, and on Methods of preventing this Effect; and on their Application to Ships of War and other Ships. By Sir Humphry Davy, Bart. Pres. R. S.*

1. The rapid decay of the copper sheeting of his Majesty's ships of war, and the uncertainty of the time of its duration, have long attracted the attention of those persons most concerned in the naval interests of the country. Having had my inquiries directed to this important object by the Commissioners of the Navy Board, and a Committee of the Royal Society having been appointed to consider of it, I entered into an experimental investigation of the causes of the action of sea water upon copper. In pursuing this investigation, I have ascertained many facts which I think not unworthy of the notice of the Royal Society, as they promise to illustrate some obscure parts of electro-chemical science; and likewise seem to offer important practical applications.

2. It has been generally supposed that sea water had little or no action on pure copper, and that the rapid decay of the copper on certain ships was owing to its impurity. On trying, however, the action of sea water upon two specimens of copper, sent by John Vivian, Esq. to Mr. Faraday for analysis, I found the specimen which appeared absolutely pure, was acted upon even more rapidly than the specimen which contained alloy: and, on pursuing the inquiry with specimens of various kinds of copper which had been collected by the Navy Board, and sent to the Royal Society, and some of which had been considered as remarkable for their durability, and others for their rapid decay, I found that they offered very inconsiderable differences only in their action upon sea water; and, consequently, that the changes they had undergone must have depended upon other causes than the absolute quality of the metal.

3. To enable persons to understand fully the train of these researches, it will be necessary for me to describe the nature of the chemical changes taking place in the constituents of sea water by the agency of copper.

When a piece of polished copper is suffered to remain in sea water, the first effects observed are, a yellow tarnish upon the copper, and a cloudiness in the water, which take place in two or three hours: the hue of the cloudiness is at first white; it gradually becomes green. In less than a day a bluish-green precipitate appears in the bottom of the vessel, which constantly

* From the Philosophical Transactions for 1824, Part I.

accumulates; at the same time that the surface of the copper corrodes, appearing red in the water, and grass-green where it is in contact with air. Gradually carbonate of soda forms upon this grass-green matter; and these changes continue till the water becomes much less saline.

The green precipitate, when examined by the action of solution of ammonia and other tests, appears principally to consist of an insoluble compound of copper, (which may be considered as a hydrated sub-muriate) and hydrate of magnesia.

According to the views which I developed fourteen years ago, of the nature of the compounds of chlorine, and which are now generally adopted, it is evident that soda and magnesia cannot appear in sea water by the action of a metal, unless in consequence of an absorption or transfer of oxygene. It was therefore necessary for these changes, either that water should be decomposed, or oxygene absorbed from the atmosphere. I found that no hydrogen was disengaged, and consequently no water decomposed: necessarily, the oxygene of the air must have been the agent concerned, which was made evident by many experiments.

Copper in sea water deprived of air by boiling or exhaustion, and exposed in an exhausted receiver or an atmosphere of hydrogene gas, underwent no change; and an absorption in atmospherical air was shown when copper and sea water were exposed to its agency in close vessels.

4. In the Bakerian Lecture for 1806, I have advanced the hypothesis, that chemical and electrical changes may be identical, or dependent upon the same property of matter: and I have farther explained and illustrated this hypothesis in an elementary work on chemistry, published in 1812. Upon this view, which has been adopted by M. Berzelius and some other philosophers, I have shown that chemical attractions may be exalted, modified, or destroyed, by changes in the electrical states of bodies; that substances will only combine when they are in different electrical states; and that, by bringing a body naturally positive artificially into a negative state, its usual powers of combination are altogether destroyed; and it was by an application of this principle that, in 1807, I separated the bases of the alkalies from the oxygene with which they are combined, and preserved them for examination; and decomposed other bodies formerly supposed to be simple.

It was in reasoning upon this general hypothesis likewise, that I was led to the discovery which is the subject of this paper.

Copper is a metal only weakly positive in the electro-chemical scale; and, according to my ideas, it could only act upon sea water when in a positive state; and, consequently, if it could be rendered slightly negative, the corroding action of sea water

upon it would be null; and whatever might be the differences of the kinds of copper sheeting and their electrical action upon each other, still every effect of chemical action must be prevented, if the whole surface were rendered negative. But how was this to be effected? I at first thought of using a Voltaic battery; but this could be hardly applicable in practice. I next thought of the contact of zinc, tin, or iron: but I was for some time prevented from trying this, by the recollection that the copper in the Voltaic battery, as well as the zinc, is dissolved by the action of diluted nitric acid; and by the fear that too large a mass of oxidable metal would be required to produce decisive results. After reflecting, however, for some time on the slow and weak action of sea water on copper, and the small difference which must exist between their electrical powers; and knowing that a very feeble chemical action would be destroyed by a very feeble electrical force, I resolved to try some experiments on the subject. I began with an extreme case. I rendered sea water slightly acidulous by sulphuric acid, and plunged into it a polished piece of copper, to which a piece of tin was soldered equal to about 1-20th of the surface of the copper. Examined after three days, the copper remained perfectly clean, while the tin was rapidly corroded: no blueness appeared in this liquor; though, in a comparative experiment, when *copper alone* and the same fluid mixture was used, there was a considerable corrosion of the copper, and a distinct blue tint in the liquid.

If 1-20th part of the surface of tin prevented the action of sea water rendered slightly acidulous by sulphuric acid, I had no doubt that a much smaller quantity would render the action of sea water, which depended only upon the loosely attached oxygene of common air, perfectly null; and on trying 1-200th part of tin, I found *the effect* of its preventing the corrosion of the copper perfectly decisive.

5. This general result being obtained, I immediately instituted a number of experiments, in most of which I was assisted by Mr. Faraday, to ascertain all the circumstances connected with the preservation of copper by a more oxidable metal. I found, that whether the tin was placed either in the middle, or at the top, or at the bottom of the sheet of copper, its effects were the same; but, after a week or ten days, it was found that the defensive action of the tin was injured, a coating of sub-muriate having formed, which preserved the tin from the action of the liquid.

With zinc or iron, whether malleable or cast, no such diminution of effect was produced. The zinc occasioned only a white cloud in the sea water, which speedily sunk to the bottom of the vessel in which the experiment was made. The iron occasioned a deep orange precipitate; but after many weeks, not the smallest portion of copper was found in the water; and so

far from its surface being corroded, in many parts there was a regeneration of zinc or of iron found upon it.

6. In pursuing these researches, and applying them to every possible form and connexion of sheet copper, the results were of the most satisfactory kind. A piece of zinc as large as a pea, or the point of a small iron nail, were found fully adequate to preserve forty or fifty square inches of copper; and this, wherever it was placed, whether at the top, bottom, or in the middle of the sheet of copper, and whether the copper was straight or bent, or made into coils. And where the connexion between different pieces of copper was completed by wires, or thin filaments of the fortieth or fiftieth of an inch in diameter, the effect was the same; every side, every surface, every particle of the copper remained bright, whilst the iron or the zinc was slowly corroded.

A piece of thick sheet copper, containing on both sides about sixty square inches, was cut in such a manner as to form seven divisions, connected only by the smallest filaments that could be left, and a mass of zinc, of the fifth of an inch in diameter, was soldered to the upper division. The whole was plunged under sea water; the copper remained perfectly polished. The same experiment was made with iron: and now, after a lapse of a month, in both instances, the copper is as bright as when it was first introduced, whilst similar pieces of copper, undefended, in the same sea water, have undergone considerable corrosion, and produced a large quantity of green deposit in the bottom of the vessel.

A piece of iron nail about an inch long was fastened by a piece of copper wire, nearly a foot long, to a mass of sheet copper, containing about forty square inches, and the whole plunged below the surface of sea water; it was found, after a week, that the copper was defended by the iron in the same manner as if it had been in immediate contact.

A piece of copper and a piece of zinc soldered together at one of their extremities, were made to form an arc in two different vessels of sea water; and the two portions of water were connected together by a small mass of tow moistened in the same water: the effect of the preservation of the copper took place in the same manner as if they had been in the same vessel.

As the ocean may be considered, in its relation to the quantity of copper in a ship, as an infinitely extended conductor, I endeavoured to ascertain whether this circumstance would influence the results; by placing two very fine copper wires, one undefended, the other defended by a particle of zinc, in a very large vessel of sea water, which water might be considered to bear the same relation to so minute a portion of metal as the sea to the metallic sheeting of a ship. The result of this experiment was the same as that of all the others; the defended

copper underwent no change; the undefended tarnished, and deposited a green powder.

Small pieces of zinc were soldered to different parts of a large plate of copper, and the whole plunged in sea water: it was found that the copper was preserved in the same manner as if a single piece had been used.

A small piece of zinc was fastened to the top of a plate of polished copper, and a piece of iron of a much larger size was soldered to the bottom, and the combination placed in sea water. Not only was the copper preserved on both sides in the same manner as in the other experiments, but even the iron; and after a fortnight, both the polish of copper and the iron remained unimpaired.

7. I am continuing these researches, and I shall communicate such of them as are connected with new facts, to the Royal Society.

The Lords Commissioners of the Admiralty, with their usual zeal for promoting the interests of the Navy by the application of science, have given me permission to ascertain the practical value of these results by experiments upon ships of war; and there seems every reason to expect (unless causes should interfere of which our present knowledge gives no indications) that small quantities of zinc, or which is much cheaper, of malleable or cast iron, placed in contact with the copper sheeting of ships, which is all in electrical connexion, will entirely prevent its corrosion. And as negative electricity cannot be supposed favourable to animal or vegetable life; and as it occasions the deposition of magnesia, a substance exceedingly noxious to land vegetables, upon the copper surface; and as it must assist in preserving its polish, there is considerable ground for hoping that the same application will keep the bottoms of ships clean, a circumstance of great importance both in trade and naval war.

It will be unnecessary for me to dwell upon the economical results of this discovery, should it be successful in actual practice, or to point out its uses in this great maritime and commercial country.

I might describe other applications of the principle to the preservation of iron, steel, tin, brass, and various useful metals; but I shall reserve this part of the subject for another communication to the Royal Society.

Article III.

An Application of Mathematics to Chemical Analysis. By Mr. John Davies, M.W.S. Member of the Literary and Philosophical Society of Manchester, &c.

(To the Editors of the *Annals of Philosophy.*)

GENTLEMEN, *Manchester, July* 4, 1824.

To determine the quantities of lime and of magnesia when they occur together, has been regarded as a problem of some difficulty; and though several eminent chemists, who have paid particular attention to the subject, have suggested peculiar methods for the purpose, an accurate and a direct process is, if I mistake not, still a desideratum.

It occurred to me a short time ago that the object might be best attained by the aid of calculation, applied in a manner which, though very simple and easy, has not, I believe, been hitherto attempted. The method which will be explained in this paper will furnish another example, in addition to the many already known, of the value of the atomic theory in its subservience to chemical investigation.

I designate by the name of atomic multipliers those numbers, whether whole or fractional, by which if we multiply the weight of an atom of any base, we shall obtain that of the corresponding salt. Now it appears from the table * of chemical equivalents, that when the number denoting the weight of an atom of magnesia is multiplied by 3, and that of an atom of lime by $\frac{17}{7}$, we obtain the numbers representing the relative weights of the sulphates of those earths.

Suppose, then, that we have a quantity of lime and magnesia weighing together 96 grains, and that, when converted into sulphates, their joint weight is $265\frac{1}{7}$ grains; it is required to determine by calculation the quantity of each earth.

Assume x = the quantity of magnesia, and
y = lime.
Then $x + y = 96$,
And $3x + \frac{17}{7}y = 265\frac{1}{7}$.

Hence $x = 56$, the quantity of magnesia, and $y = 40$, that of lime.

If any objection be conceived to arise from the difficulty of procuring the earths in a pure state, it might evidently be obviated by taking the bases in the state of nitrates or any

* Henry's Chemistry, vol. ii. pp. 637 and 638.

other salts, and then converting them into sulphates. Having determined in this way the respective quantities of the given salts, those of the earths may be deduced by simple proportion.

It is easy to get a general formula for all similar cases. Let the atomic multiplier of any simple body, A, to form a given salt, be a; and that of another, B, b; and let the joint weight of the simple bodies be m, and that of their salts S; the absolute weights of A and B may be found as follows:

$$x + y = m,$$
$$ax + by = S,$$

from which equations we obtain $y = \frac{am \smile s}{a \smile b}$, and $x = \frac{s \smile bm}{a \smile b}$.

The preceding question may be readily answered by means of the general formula, the use of which it will serve to illustrate.

$$x = \frac{s - bm}{a - b} = \frac{265\frac{1}{2} - \left(\frac{17}{7} \times 96\right)}{3 - \frac{17}{7}} = \frac{1856 - 1632}{4} = \frac{224}{4} = 56,$$ the

quantity of magnesia, as before: and $96 - 56 = 40 =$ the lime.

The algebraical result from the general equation furnishes the following

Rule.

Multiply the joint weight of the bases by the atomic multiplier of one of them (A); then the difference between this product and the weight of both salts, divided by the difference between the atomic multipliers, will give the absolute weight of the other base (B).

The base A may be found by subtraction.

The principle upon which the above rule is founded may be extended to three or more bodies.

Let a, b, c, be the multipliers of the sulphates,
And a', b', c', nitrates.

Then, by denoting the respective quantities of base by x, y, and z, we have,

$$\left\{\begin{array}{l} x + y + z = m \\ ax + by + cz = s \\ a'x + b'y + c'z = n \end{array}\right\}$$

Hence the respective values of x, y, and z, may be determined.

Article IV.

Analysis of the Metal of the Statue found at Lillebonne, near Caudebec, in the Department of the Lower Seine, on an Estate belonging to M. Holley. By M. Vauquelin.*

M. Vauquelin received a portion of the metal from M. Revers, who described the statue, and a further supply from the proprietor, M. Holley. The whole quantity weighed about 340 grains. Its surface had a slight green coat of carbonate of copper, and some traces of gilding still remained. Internally, there were cavities lined with the green carbonate, and several grains of metallic copper were disseminated through the mass.

By treatment with diluted sulphuric acid, the red-brown colour of the metal assumed at once a purple hue, which as the liquor became clear changed to blue. Consequently the metal did not consist wholly of protoxide of copper, as in that case the acid would not have been coloured.

Hydrochloric acid was scarcely coloured green by digestion on the residuum; the solution deposited on cooling crystals of chloride of lead, and a considerable quantity of white proto-muriate of copper. The remainder, which was perfectly metallic, dissolved in nitric acid, leaving a residuum of white oxide of tin.

The separate analyses of several small portions of the metal gave the proportion of lead always the same, whence M. Vauquelin concludes that it is uniformly distributed through the whole mass, and not derived from solder, of which he could not discover any indications on the portions sent to him.† He supposes the lead to have been contained in the tin, with which the copper was originally alloyed, and that its proportion to the tin is as 1 : 4, a proportion very different from that employed to form common solder, but nearly the same as is used by the pewterers for their pewter. It may, indeed, be said that the solder of the ancients was not like ours, and that their pewter contained no lead; but the contrary seems most probable.

From the preceding experiments the metal appears to consist of peroxide and protoxide of copper, metallic copper, lead, and oxide of tin.

M. Vauquelin found the proportion of the gold derived from the gilding on the piece he received from M. Holley, to amount to rather more than 1-1000th part of its weight, a quantity so small that he considers it could not have been applied by means of mercury, which penetrates to a certain depth into copper, and other metals, when applied to them, and carries a portion of the

* Extracted from the Annales de Chimie.

† M. Labillardière, who first examined the metal of the statue, attributes the lead to the solder.

gold with it, of which there is no appearance below the surface in the Lillebonne statue. It was, therefore, probably, gilded by means of leaf gold, applied without the intervention of mercury, as appears also to have been the case with the Corinthian horses, which were for some time at Paris.

"I conceive that it is not necessary to have recourse to the intervention of the gilding to explain the cause of the oxidation of the statue; the presence of tin and lead appears to me to be sufficient; moreover, a metal completely gilded, does not form a voltaic pile, since the circle is closed, and the metals are in immediate contact. It is true that in the course of time solutions of continuity may take place.*

"An incipient oxidation at the surface was sufficient alone to effect the oxidation of all the parts of the statue, provided it were in a moist aerated ground. We often find in the earth copper, which externally is in the state of peroxide, internally in that of protoxide, and metallic in the centre. Iron also is frequently seen peroxidated at the surface, and in the state of protoxide in the interior. As soon as oxygen has seized on a metal in a moist place, it is propagated successively towards the interior, like, as it were, a gangrenous point, and is replaced by that at the surface, as is particularly remarkable on iron; the moment a spot of rust is formed on it, it extends in all directions."

To this abstract of M. Vauquelin's paper, we shall add a note on the same subject addressed by M. Houtou Labillardière to the Editors of the Annales de Chimie. The subject receives additional interest at the present moment from its analogy to the important question that has for some time occupied the attention of our illustrious countryman, and afforded him another opportunity of exalting the splendour of his own fame, and of benefiting his country. Our readers will see in another part of this number of the *Annals* the details of Sir Humphry Davy's experiments on the means of preventing the action of sea water on the copper sheeting of our ships, and the simple but sagacious train of reasoning which led to their institution. We must confess that M. Labillardière's explanation of the oxidation of the Lillebonne statue, is much more satisfactory to us than M. Vauquelin's. Indeed that gentleman's hypothesis seems irreconcileable to the fact; for tin and lead being positive metals with respect to copper, should rather prevent than promote its oxidation. J. G. C.

Note on the Lillebonne Statue. By M. Houtou Labillardière, Professor of Chemistry at Rouen.

We cannot, with any probability, suppose that the ancients

* M. Labillardière ascribes the oxidation to the galvanic influence of the gilding.

formed the Lillebonne statue of matter so friable as that of which it is now composed, since a slight effort is sufficient to break off pieces of it of considerable thickness: it is besides impossible to admit that conclusion, for many parts of the statue have been fixed by rivets; neither can we imagine that the oxidation of the metals, which in some parts is complete, and in others partial, can have been occasioned by any accidental calcination that the statue may have undergone. Theory and experience prove that were the oxidation owing to the combined action of heat and air, those parts completely oxidated in which the copper is found in the state of protoxide, ought to be in that of deutoxide.

There is a fact which deserves to be collated with the present subject. Most bronze medallions found under the same circumstances as the statue, have suffered an analogous alteration, which we may attribute to their having also been gilded (as we know they frequently were), for common medals which were not gilt, though found likewise under similar circumstances, either retain their metallic properties, or pass to the state of verdigris, like copper utensils exposed to air and moisture.

The oxidation of the metals of which the statue was originally formed, is derived from a particular cause ascribable to the galvanic effects produced by the contact of the gold leaf with which one of its surfaces was covered, with the copper or bronze, which forms its basis.

We know that two dissimilar metals develope electricity by contact; that they assume different electrical states; and that in the case of copper and gold, the gold becomes negative, and the copper positive. A voltaic pile constructed of those two metals, and having its copper extremity, or positive pole, terminated by a copper wire, and its gold extremity, or negative pole, terminated by a gold wire; if we place these two wires in a vessel of water, and put the pile in action, the water is decomposed, its oxygen goes to the positive pole, and combines with the copper wire, while the hydrogen, being incapable of combining with the gold wire of the negative pole, to which it is determined, flies off in the form of gas.

The Lillebonne statue, formed chiefly of copper alloyed with a small quantity of tin, and covered with leaf gold, may be considered as a voltaic pile, capable of producing the same effects as a pile whose elements consist of gold and copper. The statue having been buried for twelve or fifteen centuries in moist earth, determined the decomposition of the water by galvanic action, like the pile in the preceding case. The oxygen of the decomposed water went to the copper and combined with it; the hydrogen went to the gilded surface, and from thence escaped into the atmosphere. The number of years that the statue laid

buried allows us to conclude that this action, though slow, has been sufficient to produce such marked effects of oxidation.

The same reasoning is applicable to many other phænomena, which are daily occurring before our eyes. It is for this reason, for instance, *that we are obliged to attach the copper sheeting of our ships with copper nails, and not with nails made of iron,* that the contact of two dissimilar metals may not give rise to an electrical action, which, by the decomposition of the water, would speedily determine the oxidation of the iron, the copper in this case being negative.

Article V.

Extraction of Selenium from the sulphureous Deposits left in the Manufacture of Sulphuric Acid from Pyrites. Translated from the German of M. Lewenau, by M. Robinet.*

M. Lewenau has presented a monograph on selenium to the Société de Pharmacie. Having been desired to extract whatever is interesting and new in the Memoir, I have been occupied in examining the work. It gives a complete history of the discovery, properties, and modes of obtaining selenium, condensing in one view all that is known of this substance, from the several accounts that have been published respecting it, since M. Berzelius discovered it in 1818. But independently of what he has borrowed from others, M. Lewenau's treatise contains observations which belong to himself alone, and have appeared nowhere else; they deserve the attention of chemists in general. M. Lewenau has been principally occupied with the methods of preparing selenium, and the following is the process he has adopted. I give it exactly as he has detailed it.

"One pound of the deposit was introduced into a tubulated retort, of the capacity of four pints, taking care that none should adhere to the sides; the retort was placed on the sand-bath, and a large globular receiver, united by a Woulf's tube to a flask full of water, adapted to it. The apparatus being luted, the acid was introduced, in the proportion of eight pounds of muriatic acid, sp. gr. 1·200, to four pounds of nitric acid, sp. gr. 1·500. To avoid the effects of the violent action which suddenly takes place, only a fourth part of the acid was introduced at first, and carefully poured over the bottom of the retort by means of a funnel with a long neck. The mass immediately began to heat and swell up, and to give off a considerable quantity of red vapours. The liquid assumed a dark-grey colour, and

* From the Journal de Pharmacie.

the water in the Woulf's bottle soon became reddish-yellow. When the action of the acid had moderated, a pound and a half more was added; the same phænomena occurred again, and were followed by a fresh introduction of acid. Next, to complete the action of the acid, and get rid of the now inert liquid, it was distilled over into the receiver, with a gentle heat; the distillation was accompanied by the disengagement of a reddish-yellow gas; towards the end of the process, the neck of the retort was lined with small yellow stellated crystals, very probably a binary compound of selenic and muriatic acid, which disappeared on increasing the heat. When almost the whole of the exhausted liquid was thus separated, the remainder of the acid was introduced, in separate portions, as before. The action was always very violent on each addition of fresh acid, and it was necessary several times to change the water in the flask, as it became saturated with the acid vapours. At last, all the liquors were returned into the retort and redistilled. The insoluble residuum, and the sides of the retort, appearing of a deep-red colour, as if occasioned by pure precipitated selenium, the solubility of which in fuming nitric acid had been demonstrated by direct experiment, a pound and a half of that acid was introduced into the retort, and distilled with a gentle heat till no supernatant liquid remained, but without entirely reducing the residuum to dryness. Distilled water was affused over the residual mass at the bottom of the retort, made to boil, and the whole then poured out and filtered, and the residuum washed, till the washings passed off perfectly insipid. The filtered liquid had a light-yellow colour; that which had been distilled into the receiver was found to be slightly seleniferous.

"In order to separate the selenium from the filtered liquor, in which it existed as selenic acid, without regard to the metals it might contain, *sulphite of ammonia, recently prepared,* was employed, which threw down the selenium, in the form of large flakes, of a cinnabar-red colour. The colour was proportionately brighter, as the quantities precipitated were smaller. The precipitation was instantaneous, and preceded by slight turbidness for a few moments, when a concentrated solution was acted on; but if the solution was diluted, precipitation did not ensue for some time, although a large excess of sulphite of ammonia were added, and, which is advantageous in all cases, the liquor, at first clear, became coloured (sometimes at the expiration of many hours), and at last turbid, and deposited selenium. In a certain state of dilution, the precipitate was black or dark-grey. The selenium thus obtained was washed with cold distilled water, till the washings ceased to precipitate muriate of barytes; five or six washings are commonly necessary; the selenium was then dried in the shade.

"To obtain the small portion that might still remain in the

solution from which the selenium was precipitated, it was evaporated to two-thirds of its bulk in a retort; by these means small grey spangles were obtained, possessing a metallic brilliancy, and friable between the fingers: they were *metallic* selenium. The concentrated liquor, mixed with sulphite of ammonia, afforded a fresh quantity, but this had a dirty-brown colour. The acid products of this distillation, collected in the receiver, not giving any precipitate, nor becoming turbid with sulphite of ammonia, bars of zinc were immersed in it; the liquor being previously divided into several portions, and diluted, to avoid a too violent action: selenium was thus deposited, in dark-grey flakes, with a brisk disengagement of hydrogen gas, of a peculiar odour. It is necessary to separate these flakes speedily from the liquor, or they soon disappear. The selenium thus obtained was washed and dried. It must be observed in this operation, that immediately after the precipitation of the selenium, the bars of zinc should be removed from the acid, otherwise there is danger that it may mix with the metallic particles; in that case, it is advantageous to wash them with water acidulated with sulphuric acid. Finally, it may happen that all the selenium may not be obtained by this method, for zinc does not appear to be capable of precipitating it wholly from the solution.

"By the preceding process, one pound of the sulphureous deposit afforded,

	Gros.	grs.	Grs. troy.
"Red selenium, precipitated by sulphite of ammonia	8	14	= 484·16
Dark-grey, obtained by zinc	0	48	= 39·67
Metallic	0	12	= 9·92
Impure, brown	1	0	= 59·07
	*10	2	= 592·82

"If we compare M. Lewenau's process with those successively adopted by M. Berzelius, we find it very superior to any of them. In fact, by the old methods, we perform many useless operations for the purpose of freeing the solution of selenium from all foreign substances, in order to precipitate it in a pure state. This mode had serious inconveniences, in consequence of the difficulty of separating the sulphuric acid, and the metallic oxides, without at the same time their carrying with them a portion of the selenium. M. de Lewenau avoids this, and at the same time obtains a larger product by simplifying the operation."

* The sulphureous deposit on which M. Lewenau made his experiments, was procured from a sulphuric acid manufactory in Hungary. M. Henri, jun. has repeated the process on the seleniferous sulphur from Fahlun, and obtained a much smaller proportion of selenium than was obtained by the author.—*Note by M. Robinet.*

Article VI.

On the Natural Arrangement of the Pulmonobranchous Mollusca.

By John Edward Gray, MGS.

(To the Editors of the *Annals of Philosophy*.)

GENTLEMEN, *July* 5, 1824.

Being dissatisfied with the arrangement of the air-breathing mollusca proposed by Ferrussac in his showy work on the Land and Freshwater Shells, which he appears to have thought imperfect himself, as he has proposed a new one in one of his late numbers, which I consider to be more artificial, and consequently inferior to his former order, I have sent you a sketch of their circular disposition, which I had considered as the proper linear disposition of them before the publication of Mr. W. S. Macleay's excellent views.

The animals of this order of mollusca are at once distinguished by their closed pulmonary cavity, on the parietes of which the aërating vessels are reticulated. They all breathe free air; for those animals which live constantly in water rise to the surface to replenish their stock of that fluid so essential to life. They have no operculum, and this latter character at once distinguishes the shells of this family from the *Cyclostomidæ*, which appear to be the connecting family between them and the *Turbinidæ*.

The true land animals of this group, as the slugs and snails, which may be considered as the type, are characterized by their tentacula always being capable of being withdrawn into themselves, as the finger of a glove, and by their eyes always being placed on a pedicle capable of similar retraction; whereas those which are almost constantly found in or floating on the surface of water, as the Land-ears, the Pond and Shield-snails, are furnished with contractile tentacula and have their eyes usually sessile at the base of them. The groups of this order may, therefore, be thus characterized :—

1. *Tentaculis retractilibus, oculis pedicillatis.* Terrestres.

Mollusca gasteropoda.....	Limacidæ.
Mollusca trachelipoda, pallii marginibus incrassatis	Helicidæ.

2. *Tentaculis contractilibus.* Aquaticæ.

Mollusca trachelopoda, pallii marginibus incrassatis, testæ labio multiplicato	Auriculadæ

Mollusca trachelopoda, pallii marginibus tenuibus, testæ labio sub uniplicato. } Lymneadæ.
Mollusca gasteropoda, pallio scuti-formi. Onchidiadæ.

The affinity between these families is so close that I shall not have much difficulty in pointing out their connexion one with another. Commencing with the Slugs; they are connected with the Snails by means of the genus *Testacella*, and indeed it is exceedingly difficult to draw the line of demarcation between the *Limacidæ* and the *Helicidæ* in the present imperfect state of our knowledge with regard to the animals of the latter family. But their shells may be known from those of all the other families by their mouth being closed, when the animal is at rest, by a peculiar membrane which is called an Epiphragma, or Poma. The Snails are connected to the *Auriculadæ* by means of a genus named by Ferrussac, *Partula*, which has the eyes sessile, as in the latter family, and also has the peculiarity of being ovo-viviparous: therefore, we are thus led to the *Auriculadæ*, which are mostly aquatic, or at least found in marshes. I should certainly exclude from this family the genera *Pyramidella* and *Tornatella*, which Ferrussac has added to it, and place them in the family *Turbinidæ*, for the former has an operculum like the *Trochi*, formed of many gradually enlarging, and the latter like the *Naticæ*, formed of a few rapidly increasing whorles, and they both have the pectinobranchous animals of the latter group; but I would retain the genus *Pedipes* of Adanson, which is said to be marine, in this family, on account of its near affinity to the *Auricula nitens* of Lamarck (the Voluta triplicata of Donovan), which, like several of this family, is found in salt marshes, or estuaries, and I would also add to it the *Voluta fluminea* of Dr. Maton, which, by the peculiar form of its outer lip, may perhaps form a new genus.

From this family, by the general similarity of the animals, the general habitat, and particularly by the peculiar form of the shell of *Auricula Dombeyana*, I proceed to the *Lymneadæ*, which are all truly aquatic, and usually called *Pond Snails*, and which, by the addition of the genus *Planorbis* to the divisions pointed out by me in Sowerby's Genera, will form a very complete circle. From thence, by means of the much shifted genus *Ancylus*, we are led to the *Onchidiadæ* which only differ from them in being destitute of any shell; and by means of the land section of this family, which Ferrussac has placed with the *Limacidæ*, we are led to return to that family, thus completing the circle, which, at another opportunity, I shall attempt further to illustrate.

It is impossible, till more is known of the animals of the Snails, to point out distinctly the analogy between the genera of the

families *Limacidæ* and *Helicidæ;* but as a proof that such analogy does exist, I need only observe that Ferrussac has named two of the genera of the latter family *Helicarion* and *Helicolimax*, on account of their similarity to the genera *Arion* and *Limax* of the former family.

Article VII.

Description of an improved Rain Gauge. By Mr. George Chilton, Lecturer on Chemistry.*

The quantity of rain that falls in any particular district being an important item in Meteorology, any improvement in the instruments of observation by which that quantity can be determined correctly must be acceptable to the cultivators of that department of science. In the common construction of the rain gauge several causes of error are manifest, which when taken separately, might be deemed trivial, but whose combined effect is such as every accurate observer must be desirous of avoiding. It is well known that fluids undergo changes in bulk by changes of temperature, as well as by those of barometrical pressure; and that any mode of measuring the dimensions of a fluid, exposed to the influence of these fluctuating causes, provided it does not make due allowance for them, must be erroneous.

In addition to these causes of irregularity, the cohesion of the fluid, which is necessarily connected with the measurement by graduated rods, renders it impossible to determine the true height of it.

But besides these obvious causes of inaccuracy, the fluid in the common construction of the rain-gauge is too much exposed to spontaneous evaporation. This might, in part, be remedied by narrowing the neck of the funnel, but here another difficulty arises: if the aperture, by which the water enters the gauge be too small, the funnel, in a smart shower, might be filled to overflowing; by which a part of the water would be lost.

The following is a description of a rain gauge constructed on principles, by the help of which, the quantity of rain that falls into it can be accurately determined in inches of altitude without being affected by the causes of error alluded to above.

An essential part of the rain gauge is a prismatic vessel, figs. 1 and 2 (see p. 113), whose top and bottom are, each 10 inches square, inside measure, with any convenient height.

This is all that is necessary for occasional experiments, as for instance, to determine the quantity of rain, snow or sleet, that may fall in winter when the evaporation is inconsiderable; or

* American Journal of Science.

the quantity of rain that falls in a single shower, at any other season. But to answer all purposes, it must be provided with a cover, in the centre of which is inserted a funnel, whose top has the same area as that of the top or bottom, of the prismatic vessel above. To prevent evaporation, the orifice of the funnel is furnished with a valve against which a weak spring, attached to the inside of the cover, presses with a force just sufficient to close it, but which is overcome by the weight of a few drops of rain. It is evident that in a shower the water will open the valve, and after it has passed into the body of the gauge, the valve will close the orifice again, suffering, however, the drainings of the funnel to pass along the pendant wire by cohesive attraction.

This top, with its funnel and appendages, may be fitted on the body of the gauge, like the lid of a common tea-canister.

The water being thus introduced into the gauge, the method of determining its altitude in inches and decimal parts depends upon the following fundamental statements, in connexion with the simple operation of weighing the water in the gauge.

Fundamental Principle.

A cubic inch of distilled or rain water, under a medium pressure and temperature, weighs 252·525 grains, according to the latest corrections. Now this number, multiplied by 100, the area of the funnel, in square inches, or that of the top or bottom of the body part of the gauge, gives 25252·5 grains for the weight of 100 cubic inches of water. Supposing this quantity of water in the gauge, it would evidently form a stratum on the bottom of one inch in height; and if we conceive this stratum to be divided by horizontal sections into 100 equal parts, these parts would form strata, each of which would be the $\frac{1}{100}$th of an inch in height; and, being equal to a cubic inch, would weigh 252·525 grains. Let us further suppose that one of these strata is subdivided into 10 equal parts by sections in the same direction, each of these parts would evidently form a stratum of water, whose height would be only the $\frac{1}{1000}$th part of an inch; and being equal to the 10th part of a cubic inch, would weigh 25·2525 grains.

Having then the weight of 100 cubic inches corresponding to one inch in altitude; the weight of one cubic inch to the $\frac{1}{100}$th of an inch; and the $\frac{1}{10}$th of a cubic inch to the $\frac{1}{1000}$th part of an inch; it is easy to see that the height of the water in the gauge may be obtained by making one or other of the above numbers a divisor to the corrected weight of the water, in troy grains. But this trouble is rendered unnecessary by the use of the *following tables:*—

TABLE 1. *Troy Weight.*

	Grains.
One pound troy,	= 5760
One ounce,	= 480
One drachm,	= 60
One scruple,	= 20

TABLE 2. *For reducing Avoirdupois Weight.*

	Troy grains.
One pound avoirdupois,	= 7000
Half pound,	= 3500
$\frac{1}{4}$ of a pound,	= 1750
Two ounces,	= 875
One ounce,	= 437·5
Half ounce,	= 218·75
Quarter ounce,	= 109·375

TABLE 3.

Corrected weight of water in grains troy.	Corresponding altitude in inches.	Corrected weight of water in grains troy.	Corresponding altitude in inches.
25·2525	0·001	2525·250	0·10
50·5050	0·002	5050·500	0·20
75·7575	0·003	7575·750	0·30
101·0100	0·004	10101·000	0·40
126·2625	0·005	12626·250	0·50
151·5150	0·006	15151·500	0·60
176·7675	0·007	17676·750	0·70
202·0200	0·008	20202·000	0·80
227·2725	0·009	22727·250	0·90
252·525	0·010	25252·500	1·00
505·050	0·020	50505·000	2·00
757·575	0·030	75757·500	3·00
1010·100	0·040	101010·000	4·00
1262·625	0·050	126262·500	5·00
1515·150	0 060	151515·000	6·00
1767·675	0·070	176767·500	7·00
2020·200	0·080	202020·000	8·00
2272·725	0·090	227272·500	9·00
		252525·000	10·00

An Example showing the Use of the Tables.

Suppose the weight of the water in the gauge corrected by subtracting the weight of the gauge, to be 20 lb. $5\frac{1}{2}$ ounces avoirdupois, required the height or number of inches of rain?

1. From Table 2.

lb.	oz.			
20	$5\frac{1}{2}$	=	1 lb. = 7000 grs. which × 20	= 14000
			4 oz.	= 1750
			1 do.	= 437·5
			$\frac{1}{2}$ do.	= 218·75
			The sum = the weight in grs.	142406·25

2. If the weight, reduced to grains, be found in Table 3, the corresponding height will be found opposite to it in the adjoining column; but as, in this example, it is not, take the nearest, *less*, number to it from the table, and subtract it from the weight of the water, marking the corresponding height in inches, &c. Enter the table a second time with the difference and take the nearest *less* number to *it*, together with its correspondent height, which subtract from the difference, and with the remainder enter the table again, if necessary, thus,

	Weight of water in grains.	Correspondent height.
The nearest number in the table, less than which must be subtracted, is	142406·25, 126262·5	500
Difference	16143·75	
The next number in the table, less than the difference, is	15151·5	0·60
which, when subtracted, leaves the remainder	992·25	
The nearest number corresponding to the remainder in the table, is.	1010·1	0·04
The sum of the corresponding heights gives Inches		5·64

It is obviously not necessary to be restricted to either the form or the size of the above described gauge. If the cylindrical form be thought to possess any advantages over that of a square prism, it is easy to find the diameter of a circle whose area shall be equal to 100 square inches, by the well-known rule, viz. $d = \sqrt{\frac{a}{\cdot 7854}}$, where d represents the diameter, a the area, and ·7854 the area of a circle, whose diameter is unity. If any other size should be thought more convenient, as, for instance, one whose area is only *half* of that of the above-described gauge, the same rule, if cylindrical, will give the corresponding diameter, or if a square-mouthed one be preferred, the side of the square is obtained by extracting the square root of fifty. But it must be remembered that whatever relation the area we pitch upon may bear to 100 square inches, the same relation will subsist between the final result, and that which is given by the tables: thus if the area of the gauge be fifty square inches, as this is the half of 100, we must take half the sum of the tabular heights for the true altitude.

It is not necessary to be very particular in the choice of a balance; a pair of good common scales will answer, with true weights, either troy or avoirdupois. The gauge may be made of

tin, or sheet iron painted or japanned, but copper is more durable. The area of the funnel, and that of the top of the body part, are the only parts that need attention in the construction. These ought to be made tolerably exact. A strong hoop should be fixed around them on the outside to preserve their figure true.

In every operation of weighing, the weight of the gauge, moistened in the inside, must be deducted from the gross weight; the remainder is the corrected weight of the water with which the tables must be entered.

In the case of hail, snow, sleet, or frozen water, being in the gauge, it is not necessary to melt its contents into water, as the changes effected by temperature and pressure make no difference in the weight.

The use of scales and weights may be dispensed with, by substituting a steelyard, so constructed that the movable weight on its arm might indicate by its position, *not the* weight, but the inches and decimal parts of its corresponding altitude, without reference to the tables, and without calculation.

The advantages of this method of finding the quantity of rain in linear inches of altitude, will be appreciated by adverting to the circumstance of our having a *tangible* quantity, as an unerring guide to that which is nearly imperceptible. Twenty-five grains and a half, a sensible quantity in a good balance, pointing out the difficultly visible division of the $\frac{1}{1000}$th part of an inch. Suppose the problem reversed; that the cubical contents of the water, or its weight, were required, from the observed altitude. The chances of error would all be against the accuracy of such a determination. The difficulties of the task, independently of the aforementioned causes of variation, would evidently be insurmountable.

I had a gauge constructed on this principle, twelve or fourteen years ago, for my friend Dr. Akerly, who informs me that it answered the end extremely well. This testimony in its favour is not among the least of those considerations that have induced me to make it more generally known.

G. C.

Fig. 1.

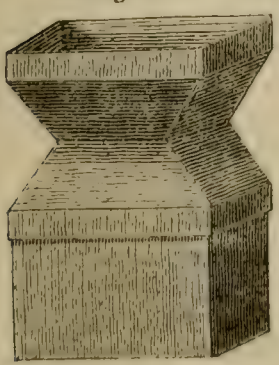


Fig. 2.

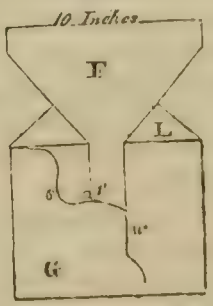


Fig. 1, represents the rain gauge in perspective.

Fig. 2, is a vertical section.

G the body of the gauge, F its funnel, L the lid or cover, *v* the valve, hinged to the lower orifice of the funnel, *s* the spring to close the valve, *w* a wire to conduct the drainings of the funnel into the body of the gauge.

Article VIII.

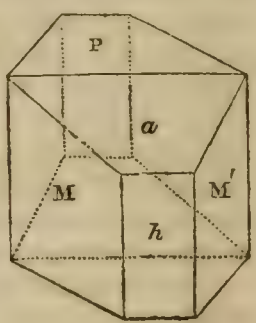
On Baryto-Calcite. By H. J. Brooke, FRS. &c.

(To the Editors of the *Annals of Philosophy*.)

GENTLEMEN, *July* 15, 1824.

Mr. Broughton, before he left London, favoured me with specimens of a mineral from Cumberland which had been considered to be carbonate of barytes, but it was very evident that the crystals did not resemble the ordinary figures of carbonate of barytes, and the substance was, therefore, regarded by Mr. Broughton as something new.

The external surface of the specimens is coated with sulphate of barytes; but the internal mass frequently contains cavities which are lined, and nearly filled with crystals. The primary form of these is an *oblique rhombic prism*, as shown in the annexed figure, the cleavage being parallel to the planes P, M, and M′.



P on M, or M′	102°	54′
P on *a*.	147	34
P on *h*	106	8
M on M′	106	54
M on *h*.	143	27

All the crystals I have seen are modified on some of the edges and angles, and are lengthened in the direction of the edges of the modifying planes, presenting the character of prisms *terminated by the bright planes* P, *a*, M, and *h*, of the figure. The modifying planes are, however, so numerous, irregular and dull in my specimens, that I have not obtained sufficiently good or corresponding measurements to enable me to ascertain their character, and they are, therefore, omitted in the drawing.

The mineral is translucent with a slight tinge of a yellowish-brown colour.

Its lustre rather more waxy than carbonate of barytes.

Its hardness is between that of carbonate and fluate of lime.

Its specific gravity, as ascertained by Mr. Children, is 3·66.

The name baryto-calcite has been given from its chemical composition, as ascertained by Mr. Children.

* The mean specific gravity of carbonate of barytes and carbonate of lime is 3·5.—C

Chemical Examination of the Baryto-Calcite. By J. G. Children, FRS. &c.

With the blowpipe this mineral exhibits the following characters.

In the forceps, in the oxidating flame, it neither fuses nor decrepitates; its surface becomes green, and the point of the flame, beyond the assay, assumes a light greenish-yellow colour. In the reducing flame the superficial green colour disappears. The assay, after being ignited, browns moistened turmeric paper.

Heated to redness, *in a glass tube*, it merely gives off a little moisture.

By heat the assay becomes strongly phosphorescent, shining with a pale-yellow light, very similar to that of the common glow-worm.

With soda, on the platina wire, in the *oxidating* flame, it gives a bluish-green opaque mass. In the *reducing* flame the green colour is discharged.

With borax, in the *oxidating* flame, dissolves readily into a perfectly diaphanous globule of a beautiful light amethystine colour. The globule retains its transparency in the *reducing* flame, but entirely loses its colour.

With salt of phosphorus, dissolves very readily; the globule is perfectly transparent, and in the *oxidating* flame yellow while hot; when cold, colourless. In the *reducing* flame the globule is colourless, and, while hot, transparent; when cold, its transparency is slightly disturbed.

Analysis.

To ascertain the proportions of its elements, I dissolved the mineral in muriatic acid, diluted the solution very largely with distilled water, and precipitated the barytes by sulphate of ammonia; boiled the precipitate to take up any sulphate of lime that might have been thrown down, filtered, and washed the precipitate, till the washings ceased to give any cloud with oxalate of ammonia, adding the washings to the solution from which the sulphate of barytes had been separated. The solution, being first reduced by evaporation, was then boiled with a solution of carbonate of potash, which threw down the lime in the state in which it originally existed in the mineral. Treated in this manner, 20 grs. gave

	Grains.
Sulphate of barytes 15·55 grs. = carbonate of barytes	13·18
Carbonate of lime.	6·72
	19·90

A minute portion, not exceeding one or two-tenths of a grain,

remained undissolved, and consisted chiefly of sulphate of barytes. Traces of iron and manganese were also obtained, as previously indicated by the blowpipe, but I could not detect any appearance of magnesia. The mineral effervesces of course very strongly with acids, and, when finely pulverised, its powder has a very light flesh-coloured or rosy tint.

According to Brande's Table of Prime Equivalents, the weight of the atom of carbonate of barytes is to that of carbonate of lime as 100 : 50, or as 2 : 1. The theoretical composition of this mineral, therefore, (disregarding the insoluble sulphate, and the metallic oxides, as not essential to it) accords very nearly with that obtained by experiment, as appears below :

	Theoretical.	Experimental.
Carbonate of barytes	66·66	65·90
Carbonate of lime.	33·33	33·60
	99·99	99·50

Hence we may consider it as containing an atom of each element.

Article IX.

On the Transmission of Electricity through Tubes of Water, &c. By Mr. Lewthwaite.

(To the Editors of the *Annals of Philosophy.*)

GENTLEMEN, *Rotherhithe, July* 9, 1824.

Allow me to intrude myself on your pages to correct an error committed by Mr. Woodward in the last number of the *Annals.*

Mr. W. says, the effects of electricity on loose gunpowder when transmitted through tubes of water, were communicated by me to Mr. L. some time previous to the publication of his letter.

The natural inference to be drawn from this sentence is, that I am indebted to him for the experiment in question. This, I can assure Mr. W. is not the case; it was originally communicated to me by Mr. Tuther about fourteen years ago. The experiment relative to the conducting power of ether, alcohol, and acids, published in the Institution Journal, originated while I was experimenting with the water tube, nor had I the least idea that Mr. W. was investigating the conducting power of those fluids until some time after the publication of my letter.

I am, Gentlemen, your humble servant,

John Lewthwaite.

P. S. An account of the experiment of firing loose gunpowder by the water tube may be found in Imison's Elements of Science and Arts, vol. i. p. 469.

Article X.

On the Nature of the Acid and Saline Matters usually existing in the Stomachs of Animals. By William Prout, MD. FRS.*

That a free, or at least an unsaturated acid usually exists in the stomachs of animals, and is in some manner connected with the important process of digestion, seems to have been the general opinion of physiologists till the time of Spallanzani. This illustrious philosopher concluded, from his numerous experiments, that the gastric fluids, when in a perfectly natural state, are neither acid nor alkaline. Even Spallanzani, however, admitted that the contents of the stomach are very generally acid; and this accords not only with my own observation, but with that, I believe, of almost every individual who has made any experiments on the subject.

With respect to the nature of this acid, very various opinions have been entertained. Some of the older chemists seem to have considered it as an acid, *sui generis;* by others it was supposed to be the phosphoric, the acetic, the lactic acid,† &c. No less various have been the opinions respecting its origin and use; some supposing that it is derived from the stomach itself, and is essential to the digestive process; others, that it is derived from the food, or is a result of fermentation, &c.; in short, there seems to be no physiological subject so imperfectly understood, or concerning which there has been such a variety of opinions.

The object of the present communication is to show, that the acid in question is the *muriatic acid,* and that the salts usually met with in the stomach are the alkaline muriates. As to the origin and use of these principles, as well as the occasional appearance of other acids, &c. in the stomach, I reserve what I have to say on these subjects till a future opportunity, and shall merely remark at present, that the facts now adduced seem to be intimately connected, not only with the physiology and pathology of the digestive process, but with other important animal functions.

Having ascertained the circumstances above-mentioned in a general manner, and by means which it would be here unnecessary to detail, an attempt was made to contrive some unexcep-

* From the Philosophical Transactions for 1824, Part I.

† After I had discovered the principal fact related in this paper, I was surprised to find how nearly Scopoli had come to the same conclusion. He did not indeed come to the conclusion, as far as I can ascertain, that free muriatic acid exists in the stomach, but he advanced the opinion, that the muriatic acid, in union with ammonia, found in such abundance in the stomach of ruminating animals, is secreted by that organ itself. The only account of Scopoli's experiments I have seen is in Johnson's Animal Chemistry, i. 183.

tionable method by which their truth might not only be satisfactorily demonstrated, but at the same time that the relative quantities of the different principles might be determined: after various attempts, the following processes were adopted for these purposes.

The contents of the stomach of a rabbit, fed on its natural food, were removed immediately after death, and repeatedly digested in cold distilled water till they ceased to impart any thing to that fluid. The whole of these different portions of fluid, which always exhibited strong and decided marks of acidity, were then intimately mixed together, and after being allowed to settle, were divided into four equal portions. 1. The first of these portions was evaporated to dryness in its natural state, and the residuum burnt in a platinum vessel; the saline matter left was then dissolved in distilled water, and the quantity of muriatic acid present determined by nitrate of silver in the usual manner; the proportion of muriatic acid in union with a *fixed* alkali, was thus determined. 2. Another portion of the original fluid was supersaturated with potash, then evaporated to dryness, and burnt, and the muriatic acid contained in the saline residuum determined as before. In this manner the *total* quantity of muriatic acid present in the fluid was ascertained. 3. A third portion was exactly neutralised with a solution of potash of known strength, and the quantity required for that purpose accurately noticed. This gave the proportion of *free* acid present; and by adding this to the quantity in union with a fixed alkali, as determined above, and subtracting the sum from the *total* quantity of muriatic acid present, the proportion of acid in union with *ammonia* was estimated. But as a check to this result, the third neutralised portion abovementioned was evaporated to dryness, and the muriate of ammonia expelled by heat, and collected. The quantity of muriatic acid this contained was then determined as before, and was always found to represent nearly the quantity of muriate of ammonia as before estimated; thus proving the general accuracy of the whole experiments beyond a doubt. 4. The remaining fourth portion of the original fluid was reserved for miscellaneous experiments, and particularly for the purpose of ascertaining whether it contained any other acid besides the muriatic. The experiments abovementioned seemed to preclude the possibility of the presence of any destructible acid; and the only known fixed acids likely to be present were the sulphuric and phosphoric; the muriate of barytes, however, neither alone, nor with the addition of ammonia, produced any immediate precipitate,* showing the

* It may be proper to remark, that ammonia, after some time, caused a flocculent precipitate, consisting of the earthy phosphates in union with vegetable and animal matter, and that after combustion, traces of sulphuric acid, the result of that process, were very perceptible. But it is evident, from the experiment related in the text, that neither of these acids previously existed in the original fluid in a free state.

absence of these two acids in any sensible quantity, and still further confirming the results as before obtained.

In this manner the three following results, selected from a variety of others of a similar nature, were obtained.

	No. 1. grs.	No. 2. grs.	No. 3. grs.
Muriatic acid in union with a *fixed alkali** ..	0·12	0·95	1·71
——————— *with ammonia*	1·56	0·76	0·40
——————— in a *free or unsaturated state* ..	1·59	2·22	2·72
Total	3·27	3·93	4·83

These results then seem to demonstrate, that free, or at least unsaturated muriatic acid in no small quantity exists in the stomach of these animals during the digestive process; and I have ascertained, in a general manner, that the same is the case in the stomach of the hare, the horse, the calf, and the dog. I have also uniformly found free muriatic acid in great abundance in the acid fluid ejected from the human stomach in severe cases of dyspepsia, as the following examples show. The original quantities of the fluids operated on of course were various, but for the sake of comparison they are reduced, in the following table, to one pint, or 16 fluid ounces, which quantity, in three instances (selected from many others), was found to contain of

	No. 1. grs.	No. 2. grs.	No. 3. grs.
Muriatic acid in union with a *fixed alkali*	12·11	12·0	11·25
——————— *with ammonia*†	0·0	0·0	5·39
——————— in a *free or unsaturated state* ..	5·13	4·63	4·28
Total	17·24	17·03	20·92

Article XI.

On the Arrangement of Papilionidæ. By J. E. Gray, MGS.

(To the Editors of the *Annals of Philosophy*.)

GENTLEMEN, *July* 7, 1824.

Mr. F. Cuvier has observed that sufficient attention has not been paid by modern naturalists to the works of Linneus, and

* For the sake of analogy, the chlorine, in union with the basis of the *fixed* alkali, is reduced in this table and the following to the state of muriatic acid.

† I have never in more than one instance (No. 3, of the above table) been able to detect any sensible quantity of the muriate of ammonia in the fluids ejected from the human stomach; and upon inquiry of Sir Astley Cooper, who was kind enough to furnish me with the fluid for examination, I was informed that the patient was in the habit of frequently taking ammonia as a medicine.

there is a great deal of truth in this remark; for it is too much the fashion to abuse without consulting them. The fact is indeed fully verified in the butterflies which Linneus divides into five groups, the *Equites*, *Heliconii*, *Danai*, *Nymphales*, and the *Phebeji*, which could only have taken place by his secretly observing their habits, according to his own maxim, for his characters are only taken from their size, colour, and the difference of the edge of the wing. Latreille has divided this family from their manners and habits into exactly equivalent groups, only placing the *Danai* between the *Equites* and the *Heliconii*, and placing the second section of the *Plebeji* in a family by themselves under the names of *Hesperiadæ*.

I have observed that whenever a group formed a good linear series, the two ends would meet, and thus form a circle, by which fact I have convinced several persons who have been disposed to doubt the truth of the circular disposition of nature. Thus we find that several series forms circles which their authors never appeared to have the slightest idea of. It is so with the slight alteration proposed by Latreille with regard to the *Papilionidæ;* and the Linnean position of the *Heliconii* in them is similar to his position of the *Cetacea* in *Mammalia;* it prevented the continuance of the series, and thus obscured their natural disposition.

In the *Equites* and the *Danai*, the larvæ are long and cylindrical, and the chrysalis is angular, and inclosed in a kind of case, or suspended by a transverse thread; in the former of these, the lower pair of wings are generally extended at their hinder angles into a tail, in the males at least, and in both they are furnished with a connecting nerve. From the latter of these groups by means of some of the *Pontiæ* of Fabricius as *P. sinapis*, we pass to the *Heliconii* and the *Nymphales*, in both of which the chrysales are suspended without any case by their hinder extremity, and their front pair of legs are folded up, in the males at least, so as to be useless in walking, and the lower pair of wings, like the *Danai*, are usually destitute of tails and connecting nerve. From these last, by means of the genus *Libithea* of *Fabricius*, we pass to the *Plebeji*, where the larva and pupa are short, and the latter is inclosed in a case, and where the lower wings are destitute of any connecting nerve, but are often provided with several tails; from these we may return to the *Equites*, for this last group has the cased pupa and the tailed wings of that tribe, and some of them appear to have a very great affinity to it.

The *Hesperiadæ* has very great affinity to the *Plebeji*, of which Linneus regarded them as a section, but I am inclined to consider them as the osculant group between the *Papilionidæ* and the *Spingidæ*, excluding from it the genus *Urania*, which appears to be the osculant on the other side between the *Papilionidæ* and the day-flying *Phalænidæ*, but adding to the *Hesperiadæ* the genera *Castnia* of Latreille, and *Agarista* of Leach.

Article XII.

*On the Results of some Chemical Analyses, and the Decomposition of Silica.** In an Extract of a Letter from M. Berzelius to M. Dulong.†

.....I have undertaken some experiments on uranium, in order to determine certain points which M. Arfwedson had left undecided in his excellent memoir on that metal. You are probably unacquainted with that work, though it well deserves to be known. Arfwedson has found the means of obtaining metallic uranium; he has studied its properties, and determined the composition of its oxides. With respect to the yellow oxide, however, his results are not always invariable. I have resumed the inquiry, and have completed the analysis of the uranite of Autun, which I find is a double subphosphate of lime and yellow oxide of uranium. It contains, besides, the phosphates of barytes, magnesia, manganese and ammonia. The green uranite from Cornwall is a similar compound, except that the lime is replaced by an equal number of atoms of oxide of copper. It is, therefore, a double subphosphate of copper and uranium, isomorphous, but not identical with the uranite from Autun.

I have examined the combinations of acetic acid with oxide of copper, in consequence of the analyses of those compounds published by Mr. Phillips. I have found no less than five different acetates of deutoxide of copper, in which the multiples of the base are, 1, $1\frac{1}{2}$, 2, 3, and 72‡; the third is the blue verdigris; but as it is decomposed either by cold water, or by a heat of 60° centigrade (140° Fahr.), I consider it to be composed of neutral acetate, and hydrate of copper. You will see the reasons which have induced me to form this conclusion more fully stated when you receive my memoir.

During the last six months I have been occupied on a great work on fluoric acid. One part is already printed in the Memoirs of our Academy; another is finished, but not yet published. I have examined the combinations of fluoric acid with bases, and have discovered that what were taken for fluates are double salts. I have analyzed fluo-silicic gas, and its compounds with bases. They are all formed in the same manner, and contain a quantity of fluoric acid combined with the silica, equal to twice the quantity combined with the base. Fluoric acid gives analogous compounds with the acids of titanium, colum-

* From the Annales de Chimie.

† A letter to Sir Humphry Davy on the same subjects, from M. Berzelius, was read before the Royal Society, May 20. (See *Annals of Philosophy*, vol. vii. p. 458.)

‡ A very extraordinary multiple, and probably a mistake; but so it is given in the Annales de Chimie.—C.

bium, tungsten, molybdena, chromium, selenium, antimony, and arsenic; with the hyposulphurous and sulphurous acids, and probably with the phosphorous and hypophosphorous; but I have not yet examined the latter.

Fluoric acid is one of the most convenient reagents for the analysis of inorganic substances, since it dissolves every thing that is not attacked by the other acids. It has enabled me to determine more accurately the weights of the atoms of many of those substances about which I was still in doubt. To extract alkali from minerals, it is sufficient to treat them with fluoric acid, or a mixture of fluate of lime and sulphuric acid. In attempting to reduce fluoric acid by potassium, I have succeeded in reducing silica, zirconia, and the other earths, but I have only been able to insulate silicium and zirconium. The rest decompose water with great energy. Pure silicium is incombustible, even in oxygen gas. It is not attacked by water, nitric acid, nor aqua regia, nor by caustic potash; but fluoric acid has a slight solvent action on it, particularly with the addition of nitric acid. It does not decompose saltpetre, unless in a very intense fire, but it detonates with carbonate of potash at an incipient red heat: carbonic oxide gas is disengaged, and charcoal set free. When silicium is heated with nitre, if a morsel of dry carbonate of soda be plunged into the mixture, detonation immediately ensues. By passing the vapour of sulphur over silicium heated to redness, the metal suddenly becomes incandescent. If the combination be complete, which seldom happens, the compound appears as a white earthy mass; it decomposes water with extreme rapidity, the water dissolves the silica and sulphuretted hydrogen gas is evolved. In this way we may obtain so concentrated a solution of silica in water that it thickens and coagulates during evaporation, and lets fall portions of that earth in the form of a gummy transparent mass. Siliciuret of potassium, heated with sulphur, burns vividly, and leaves, when dissolved, pure silicium. In chlorine, silicium takes fire at a red heat, and there is formed a colourless, or slightly yellow liquid, with an odour similar to that of cyanogen, extremely volatile, and which sets with water and deposits gelatinous silica. I have not yet examined how silicium conducts electricity and heat, nor its specific gravity, &c. Nothing is easier than to procure this substance; the following is the method I have adopted:—The double fluate of silica and potash, or soda, heated nearly to redness to drive off the hygrometric water, is put into a glass tube, closed at one end. Bits of potassium are added and mixed with the powder by fusing the metal and gently rapping the tube. It is then heated by the spirit-lamp, and before it is red-hot a feeble detonation ensues and the silicium is reduced. The mass is suffered to cool, and then treated with water as long as it dissolves any thing. Hydrogen

gas is at first evolved, in consequence of siliciuret of potassium having been formed, which cannot exist in water. The washed substance is a hydruret of silicium, which, at a red heat, burns vividly in oxygen gas, although the silicium is not thereby completely oxidated; it is then heated in a covered platina crucible, the heat being slowly raised to redness. The hydrogen alone is oxidated, and the silicium is now no longer combustible in oxygen; but chlorine attacks it readily. The small portion of silica that is formed may be dissolved by fluoric acid. If silicium has not been exposed to a strong red heat, the acid dissolves it, with a slow disengagement of hydrogen. According to my synthetical experiments, silica contains 0·52 of its weight of oxygen. Zirconium is obtained by an analogous process. It is as black as charcoal, is not oxidated either by water or muriatic acid, but aqua regia and fluoric acid dissolve it; the latter with disengagement of hydrogen. It burns with extreme intensity at a slightly elevated temperature. It combines with sulphur. Its sulphuret is chesnut-brown like silicium, insoluble in muriatic acid and the alkalies. It burns brilliantly, and the products are sulphurous acid gas and zirconia.

Article XIII.

On the Mineral Waters of Carlsbad. By Jac. Berzelius.*

Carlsbad is situated in a deep and very narrow valley, not far from the place where the latter terminates in the valley of the river Eger. Through the middle of this spot, there flows the little river Tepel, on both of whose banks, and within a short distance from one another, the hot springs first issue from the earth. The springs themselves are extremely numerous, but those resorted to by the strangers at Carlsbad are only the following: the Sprudel, the Hygeian spring, the Mill spring (Mühlbrunn), the New spring (Neubrunn), the Empress Theresa's spring (Theresienbrunn), St. Bernard's spring (Bernhardsbrunn), and, but much seldomer than the others, the Hospital spring (Spitalsbrunn). All of them issue from a species of limestone, and into each of the outlets there has been inserted an artificial pipe, through which the water, impelled by the internal pressure, is thrown up into the air in an uninterrupted jet, in a manner very convenient for those who drink it. This limestone is formed by the water itself; for the latter, in proportion as it loses carbonic acid, is incessantly depositing a concretion of a compact and crystalline texture, on every substance with which it comes in contact.

* Abridged from the Kongl. Vet. Acad. Handl. 1822, p. 139.

About the commencement of last century (in the years 1713 and 1727), this calcareous incrustation was suddenly burst open in consequence of the accumulated pressure from within, and the hot water flowed down immediately into the river Tepel. It was determined at that time to bore through the limestone, partly with a view to investigate the cause of these eruptions, and, if possible, to obviate the recurrence of a similar accident, and partly also with the hope of discovering the source in which the apparently inexhaustible supply of water originates. Scarcely had the external crust been broken, when the water rushed out with great violence, and numerous cavities were discovered under it, all of them filled with water, and the partitions between which rested upon a thick calcareous incrustation, similar to the one already penetrated. This also was broken through, and cavities were found beneath it, of exactly the same nature with those already described; all of them full of water, which was discharged from them with a still greater degree of force, and having another calcareous incrustation for their basis. The opening of the third vault disclosed an immense reservoir of water, which on its first discovery received the name of the Sprudelkessel. These three calcareous layers were in all from one to two yards in thickness, and consisted of a hard body, sometimes alabaster-white, sometimes brownish-coloured and striped, which commonly received the name of Sprudel-stone. They did not rest over one another in a regular concentric manner, but constituted numerous unequal cavities, which were separated by the intervening partitions: so that their general arrangement approached considerably to what would be exhibited by a number of flat basins of different sizes, when turned upside down, and heaped in an irregular manner over one another. The water in this reservoir was in a state of violent ebullition, and the copious volumes of hot steam which rushed through the opening made in it, completely prevented an accurate determination of its extent. Its depth from the outermost crust of limestone was estimated to be between three and four yards, after making allowance for the irregularities of its bottom; but it could not be fathomed in any direction by a rod 60 yards in length, and pushed forwards horizontally. Indeed, its great extent may be judged of pretty accurately from the circumstance, that in the greater part of the little town of Carlsbad, one cannot dig to any considerable depth, without meeting the calcareous shell, and when this is penetrated, the hot water instantly rushes up with its customary impetuosity. In many places the carbonic acid gas makes its way through natural clefts in the limestone, in such abundance, as to fill the cellars of the houses; and in the river Tepel (which flows to some distance immediately over the reservoir), particularly in the neighbourhood of the Sprudel, there may be observed a constant

succession of air bubbles rising to the surface of the water. The openings made in the course of this examination were built over with mason work, every joint of which became speedily stopped up with the carbonate of lime deposited by the water. It still continues to retain the water completely, and to constrain it to flow through the pipes, which have been placed in the reservoir. These pipes also become by degrees incrusted with the sprudelstone, and must be cleared four times every year to prevent their being clogged up altogether.

What is called the Sprudel is merely an opening in the reservoir, from which, however, the water rises only at intervals, in such a manner that air and water are discharged from it alternately. This remarkable phenomenon is occasioned by the carbonic acid gas, which gradually accumulates in the upper vault of the reservoir, and which, owing to the diminished pressure, the water is constantly emitting, in proportion as it recedes from the interior of the earth. This gas, having no means of exit, of necessity reacts upon and presses down the expanse below, until it at last escapes through the canal which, until then, had furnished a passage for the water. Hence air and water are discharged through the opening successively, in proportion as the elasticity of the gas accumulates and is expended.* This alternation takes place at the Sprudel 18 or 19 times every minute. There are many other openings in the immediate neighbourhood, from which the water is discharged even in greater abundance; but it proceeds from them all in an uninterrupted stream.

The quantity of hot water which flows from these springs is altogether astonishing. Many attempts have been made to estimate it; but all of these are of so indirect a nature, that they do not deserve to be regarded as even approximations to accuracy.†

Analysis of the Water.

The water employed for this analysis was taken from the Sprudel, and was preserved in bottles furnished with ground glass stoppers, in order to prevent the diminution in the quantity of oxide of iron, which is always occasioned by a common cork. The Carlsbad water is clear and colourless. When newly drawn its taste resembles that of weak chicken broth, but after some hours it becomes unpleasantly alkaline. It has no peculiar smell, nor can any reagent detect in it the minutest trace of sul-

* An ingenious illustration of a similar natural intermitting spring will be found towards the conclusion of the introductory portion of the article Steam Engine, by Prof. Robison, in the Encyclopædia Britannica; or in his System of Mechanical Philosophy, edited by Dr. Brewster, vol. ii. p. 43.

† Klaproth's estimation of this quantity is certainly twenty times too high. From a measurement made on the spot, Nov. 1, 1811, it was calculated that the Sprudel and the Hygeian spring alone discharge 192$\frac{3}{4}$ millions of German cubic feet of water every 24 hours.

phuretted hydrogen. After being kept for some time in close vessels, it deposits a very slight bright-yellow sediment, whose colour depends obviously on oxide of iron. Its specific gravity at 64½° is 1·004975; and the specific gravity of the water collected at all the different springs is identically the same.

625·4 grammes of the water were concentrated in a platinum capsule, until it began to deposit crystals. It was then thrown upon a balanced filter, and the insoluble earthy precipitate, after being strongly dried, was weighed along with the filter in a platinum crucible, in order to prevent the accession of hygroscopic moisture during the weighing. Its weight was found to be 0·324 gramme. The filtered liquid was cautiously evaporated to dryness in a balanced platinum crucible, and the residue was ignited until it began to enter into fusion, which took place before the crucible became visibly red-hot in day-light. The fused saline mass weighed 3·058 gramme. Hence 1000 parts of the water contain

Soluble salts	4·890
Earthy matter	0·518
	5·408

In many other experiments performed in a similar way, the quantity of solid ingredients was found to vary from 5·407 to 5·476. These differences are probably caused by the unequal quantities of carbonic acid which are expelled from the magnesia during desiccation.

(A.) *The Salts soluble in Water.*—Having ascertained by preliminary experiments that these contained no other base than soda, and no other acids than the sulphuric, muriatic, and carbonic, I proceeded to the analysis in the following manner:—The fused saline mass was dissolved in water; the solution was turbid, owing to the presence of some magnesia, which, collected upon a filter and ignited, weighed 0·006 gramme. The filtered liquid was saturated with acetic acid, and evaporated to dryness, with a view to determine whether the alkali retained any silica; but the dry salt redissolved completely in water without leaving any residue. Muriate of barytes being now added, precipitated a quantity of sulphate of barytes, which, washed and ignited, weighed 2·646 grammes, equivalent to 1·618 gramme of sulphate of soda. The filtered liquid was now strongly acidulated with nitric acid, and the muriatic acid was thrown down by nitrate of silver. The precipitated chloride of silver weighed 1·58 gramme. As it might be suspected that a portion of the muriatic acid had been expelled by the acetic acid, a corresponding quantity of the water (625·47 grammes) was supersaturated with nitric acid, and precipitated by nitrate of silver. 1·588 gramme chloride of silver was obtained. That

this quantity is slightly in excess over the former, is more probably caused by the difficulty of conducting the evaporation, ignition and filtrations in the course of the experiment, without loss, than by the decomposition of any portion of muriate of soda by the acetic acid. These 1·588 gramme represent 0·6495 gramme of chloride of sodium. The deficit in the total amount must have consisted of carbonate of soda: the quantity of this salt was, therefore, 0·7845 gramme.

(B.) *The earthy Salts insoluble in Water.—a.* These being mixed with nitric acid in a platinum capsule dissolved with effervescence. In order to prevent any loss of the liquid, I am in the custom, when making a solution accompanied with effervescence, and also at the commencement of the evaporation, to cover the dish with a watch-glass, the convex side of which is undermost. By this means, the whole of the liquid driven up in consequence of the disengagement of the elastic fluid, is collected upon the watch-glass, and gradually drops down from its central point, while the glass itself is washed by the water which successively condenses upon it during the evaporation. In this experiment the glass happened to have been left on the capsule until the solution had attained a state of dryness. On taking it off, its under side was found to be covered with dull spots, exhibiting distinctly the edges of the drops of water which had condensed upon it during the evaporation. As the same glass had been repeatedly employed for a similar purpose, without sustaining any alteration, it was obvious that, in this instance, fluoric acid had been disengaged, and had corroded it.

b. The dry mass was moistened with nitric acid, heated, and then dissolved in water. A dark-grey coloured silica remained undissolved, which, after ignition, became white, and weighed 0·044 gramme.

c. Ammonia produced in the filtered solution an exceedingly slight yellow-coloured precipitate, which, after ignition, weighed 0·004 gramme, and presented the appearance of oxide of iron. As fluoric acid, when occurring in the mineral kingdom, is almost always accompanied by phosphoric acid, I examined this oxide of iron before the blowpipe, and obtained from it a fused regulus of phosphuret of iron. We shall, bye and bye, find that this oxide of iron contained also silica, alumina and oxide of manganese.

d. The liquid which had been treated with ammonia was mixed with oxalate of ammonia so long as any precipitation ensued. The oxalate of lime was calcined, moistened with a solution of carbonate of ammonia, and again heated until it became just visibly red. The carbonate of lime thus formed weighed 0·195 gramme. It was dissolved in nitric acid, the solution was evaporated to dryness, and the residue was dissolved in alcohol of the specific gravity 0·793. A dark-brown

coloured substance remained, which was thoroughly washed with alcohol. Water extracted the greater portion of this substance: the solution gave with oxalate of ammonia a white precipitate, which was converted by calcination into carbonate of strontitan; but its quantity was so small that I could not determine its weight, nor indeed could I have satisfied myself completely that it consisted of strontitan, had I not succeeded in obtaining it in larger quantity from a different source. The substance insoluble in water was oxide of manganese, but also in too inconsiderable quantity to admit of being weighed with precision.

e. The solution precipitated by oxalate of ammonia was evaporated to dryness, and the saline residue decomposed by calcination. A white earth was left, weighing 0·054 gramme. Water dissolved from it 0·005 gramme of an alkaline carbonate, which neither attacked the platinum crucible in a red heat, nor did it yield a difficultly soluble salt with muriate of platinum. It was, therefore, soda; and it appears to have formed, during the evaporation of the water, an insoluble compound with the silica and the magnesia, or lime, which was first decomposed by the nitric acid.

f. The remaining 0·049 gramme of magnesia was dissolved in nitric acid, and the solution evaporated to dryness. By this means there was separated 0·002 gramme of silica, impregnated with a trace of manganese. There remains, therefore, for magnesia only 0·048 gramme.

The following are the results of this analysis:

Sulphate of soda	1·618
Carbonate of soda	0·790
Chloride of sodium	0·649
Carbonate of lime	0·195
Pure magnesia	0·054
Peroxide of iron	0·004
Silica	0·046
	3·356

The difference between 3·356 and 3·382 arises partly from unavoidable loss, and partly from the magnesia being regarded in the tabular result as completely free from carbonic acid.

Although the substances which made their appearance unexpectedly in this analysis are inconsiderable in quantity when compared with the others, it may nevertheless be worth while to examine each of them more particularly, and, if possible, to determine its amount.

1. *Quantity of the Fluoric and Phosphoric Acids, and the Manner in which they exist in the Water.*—In order to ascertain with still greater certainty that fluoric acid constitutes an ingre-

dient of the water, I pulverized a quantity of the sprudelstone which is deposited on the evaporating pans, mixed it in a platinum crucible with concentrated sulphuric acid, and covered it with a bit of glass coated with etcher's wax, and on which I had scratched a few delineations. At the end of half an hour the glass was found to be distinctly etched, and the air within the crucible had also the smell of fluoric acid.

I made numerous attempts, but for a long time fruitlessly, to separate fluoric acid immediately from the residue obtained by evaporating the water, and, in particular, from the precipitate which is produced by ammonia in a solution of the earthy matter in nitric or muriatic acid. For this purpose I ignited the precipitate, and treated it with sulphuric acid. My failure arose from the silica in the analysis of these residues, being in a peculiarly soluble condition, forming doubtless a fluosilicate, which was so thoroughly saturated with silica, that when the precipitate was calcined, the whole of the fluoric acid was volatilized in combination with the earth. Hence when I decomposed the precipitate, without subjecting it to a previous ignition with sulphuric acid, and made the extricated gas to pass through a solution of carbonate of soda, I obtained both the silica and the fluoric acid, the former diffused through the liquid, the latter in a state of solution, and easily precipitable by the usual treatment with a salt of lime. The quantity however was too small to admit of its weight being determined with precision; nor had I at my disposal a sufficient stock of the water for repeating the analysis on a larger scale. I had therefore recourse to the sprudelstone, in which I had reason to believe the carbonate and fluate of lime exist in the same relative quantities as in the water; because, as shall be subsequently proved, they are both held in solution by carbonic acid, and must therefore precipitate together in proportion as the solvent is dissipated.

The sprudelstone selected by me for this examination had been formed in the establishment where the Carlsbad salts are prepared. This establishment consists of a large basin, through which the whole of the annexed water of the Sprudel is made to flow, and in which there are placed side by side a number of flattish tin vessels also filled with the water. The tin vessels are thus situated in a kind of balneum mariæ, and they are maintained in this temperature, until the solutions contained in them begin to crystallize. On the outer side of these vessels the water in the basin deposits an incrustation of sprudelstone, which gradually increases in thickness. The thickness of the specimen which I analyzed was about a quarter of an inch. Its fracture was crystalline and striated, and its specific gravity was 2·84: in both of these characters, therefore, it had a striking resemblance to arragonite.

To determine how far the sprudelstone represents the substance deposited by the water, when deprived of its carbonic acid, I mixed a quantity of the water with caustic ammonia. It instantly became turbid, and at the end of twenty-four hours there had subsided a granular and slightly yellowish coloured precipitate. The filtered liquid when concentrated deposited a white earthy matter. The first of these precipitates contained carbonate of lime and oxide of iron, but no magnesia. The second dissolved without effervescence in acids, and left a gelatinous silica. The solution contained magnesia; oxalate of ammonia produced no alteration in it, but phosphate of ammonia precipitated from it the well known double salt of magnesia. This experiment demonstrates that the substances held in solution by the carbonic acid are precipitated in proportion as the acid is dissipated, independently of the concentration of the liquid; but that the magnesia and silica do not make their appearance until a portion of the water has been evaporated. That the magnesia in this experiment was precipitated in the state of silicate, proceeded obviously from the presence of ammonia.

The constituents of the sprudelstone represent therefore the carbonate of lime and oxide of iron obtained in the analysis; and, consequently, by analyzing a larger quantity of that incrustation, it might be possible to discover the proportion in which the fluoric acid, the phosphoric acid, the oxide of iron, and the strontian, exist in the water, when compared with the carbonate of lime.

a. I reduced a quantity of the above incrustation (pannsten) to an impalpable powder, and boiled it repeatedly in distilled water, in order to separate any soluble saline matter which the water might have deposited among its particles. This was afterwards thoroughly dried. 10 grammes of the powder thus purified were dissolved in dilute nitric acid. Some oxide of iron remain undissolved, but was speedily taken up on the application of heat. After the carbonic acid gas had been completely expelled, the solution, which had a slight tinge of colour, was filtered. A grayish powder, weighing 0·001 gramme, was by this means separated: before the blowpipe with carbonate of soda in platinum foil it gave traces of manganese, and on charcoal it left a globule of tin.

b. The filtered liquid was decomposed in a close vessel with caustic ammonia. A light yellowish coloured matter precipitated, which, after ignition, became brown, and weighed 0·157 gramme. It was analyzed in the following manner. Sulphuric acid mixed with it in a platinum crucible occasioned after a few moments the disengagement of fluoric acid, and a glass prepared in the usual way, when placed over the crucible, became deeply etched. As the gas was not expelled instanta-

neously and with effervescence, it is probable that the precipitate contained no silica. When the fluate of lime had been fully decomposed, the residual saline mass was boiled in as much water as was sufficient to take up the whole of the sulphate of lime. The solution, mixed with ammonia, gave a yellow coloured precipitate resembling oxide of iron, and weighing after ignition 0·06 gramme.

c. The solution, separated from the above precipate, was decomposed by oxalate of ammonia. The oxalate of lime thus formed, left, after calcination, 0·127 gramme of carbonate of lime, equivalent to 0·099 gramme of fluate of lime.

d. The oxide of iron from *b*, was dissolved in muriatic acid; a white matter, weighing 0·001 gramme, remained undissolved, which, when heated with an alkali on charcoal before the blowpipe, was converted into a globule of tin. The solution was combined almost to saturation with sal ammoniac,* and triple prussiate of potash was added, until the whole of the oxide of iron was precipitated. The whole was then filtered, and the precipitate was washed with a solution of sal ammoniac. The filtered liquid, mixed with ammonia, gave a white flocky precipitate, weighing after ignition 0·015 gramme. This was dissolved in muriatic acid, and the solution was mixed with an excess of caustic potash. 0·006 gramme phosphate of lime precipitated. What remained dissolved in the alkali was separated by saturation with muriatic acid, and by the subsequent addition of ammonia. It fell as a white precipitate, which, however, gradually became pale amber coloured on being dried. Before the blowpipe, nitrate of cobalt developed in it a deep but rather impure blue colour, with carbonate of soda on the platinum foil it indicated traces of manganese, and with boracic acid and iron it yielded a fused button of phosphuret of iron. It consisted therefore of subphosphate of alumina, containing traces of phosphate of manganese. The liquid from which the subphosphate of alumina and phosphate of lime had been precipitated, being mixed with lime water, gave 0·003 gramme of phosphate of lime, whose acid (0·00135 gramme) must have been combined with oxide of iron. Subtracting this along with the weight of the other substances separated in *d*, from the 0·06 gramme in *b*, we obtain for the quantity of oxide of iron 0·0426 gramme. The sum of the weights of all these substances corresponds almost exactly with the quantity originally submitted to analysis: an additional proof that the fluoric acid existed in the precipitate uncombined with silica. Had the contrary happened, a considerable loss would have been sus-

* Sal ammoniac was added, because a liquid containing an excess of the triple prussiate has the property of dissolving a considerable quantity of the blue precipitate; but this is prevented by the presence of the dissolved salt.

tained, because the fluosilicate of lime, which is precipitated by ammonia, contains much less lime than the fluate of lime.

e. Another quantity of the pulverized sprudelstone was heated to redness in a small apparatus, in which the gaseous substances disengaged were made to pass over fused muriate of lime. The total loss amounted to 2·39 per cent; of which 1·59 consisted of water, and 0·8 of carbonic acid. By subtracting the former of these quantities 1·59 from the portion of the dissolved sprudelstone which was not precipitated by ammonia, it is easy to obtain the quantity of carbonate of lime. Hence we find that the powder subjected to analysis contained per cent. 96·77 of carbonate of lime, 0·06 of phosphate of lime, 0·99 of fluate of lime, and 0·1 of phosphate of alumina. The oxide of tin is here neglected, because it does not proceed from the water; so also is the oxide of iron, because the sprudelstone does not always contain it in the same proportion with the other ingredients of the water, its deposition appearing to be more influenced by the accession of atmospheric air, than by the expulsion of carbonic acid. This is the reason why the sprudelstone contains a variable quantity of oxide of iron, and why it is in general marked with brown stripes.

According to these data, 1000 parts of the Carlsbad water analyzed by me must have contained

Fluate of lime	0·00320
Phosphate of lime	0·00022
Subphosphate of Alumina	0·00032

As no silica is deposited along with the fluate of lime in the sprudelstone, it follows that the water itself contains no fluosilicate of lime.

2. *Determination of the quantity of Strontian.*—I employed for this purpose the liquid which had been precipitated by ammonia, in the foregoing analysis. It was evaporated to dryness, and the saline residue was treated with a slight excess of nitric acid, in order to decompose the carbonate of lime, which had been formed in consequence of the ammonia having absorbed carbonic acid during the evaporation. The nitrate of ammonia was now destroyed by ignition; and the nitrate of lime, which constituted nearly the whole of the remaining salt, was dissolved out by alcohol. A small quantity of a white matter was left behind; being dissolved in water and precipitated by oxalate of ammonia, and the precipitated oxalate being calcined, it was converted into an earthy carbonate weighing 0·03 gramme. That this was carbonate of strontian, and that it did not proceed from any salt of lime which had been left undissolved by the alcohol, was demonstrated by the following circumstances: with muriatic acid it gave a salt in

radiated crystals, which was not deliquescent; these were somewhat soluble in alcohol, and cotton, moistened with the solution, burned with a red coloured flame; and finally, which indeed I consider the most decisive character of all, they dissolved in a saturated solution of sulphate of lime, but at the same instant rendered it exceedingly turbid, in consequence of the formation of a difficultly soluble sulphate of strontian. Muriatic acid rendered the liquid again transparent: in proof that the precipitate did not consist of sulphate of barytes. It follows from this experiment that 1000 parts of the water contain 0·00096 of carbonate of strontian.

3. *Quantity of the Oxides of Iron and Manganese.*—The analysis of the sprudelstone already demonstrated that the 0·004 gramme regarded as oxide of iron in the original analysis of the water, was not that substance in a state of purity, but contained sensible quantities of silica, phosphate of alumina, phosphate of manganese, and phosphate of lime. To determine the quantity of oxide of iron with greater precision, 4·107 grammes of the insoluble earthy matter from the Carlsbad water were dissolved in nitric acid, and the solution was mixed with an excess of ammonia. From the unignited precipitate sulphuric acid expelled some fluosilicic acid, which, with a view to ascertain its quantity, was made to pass through a solution of carbonate of soda. The sulphuric solution being precipitated by ammonia, the filtered liquid contained no lime: consequently the fluoric acid and silica had been combined with oxide of iron. Potash boiled on the precipitate, left 0·02 gramme of oxide of iron undissolved; and, from the alkaline solution, there was separated in the usual manner 0·004 gramme phosphate of alumina, mixed with some manganese. Lime water added to the remaining liquid, threw down a small quantity of phosphate of lime. As the oxide of iron might have been contaminated with phosphate of lime, it was dissolved in muriatic acid, and precipitated by the triple prussiate of potash; but no traces of phosphate of lime could be detected in the filtered liquid.

The solution from which the oxide of iron and alumina had been precipitated, was now mixed with oxalate of ammonia. It yielded 2·514 grammes of carbonate of lime. If we estimate the quantity of oxide of iron according to this quantity of lime, we shall find its amount in 1000 parts of the water to be 0·00248. The quantity of phosphate of alumina here found is rather greater than that obtained in the analysis of the sprudelstone; but this is partly owing to its not having been so completely freed from silica.

That in these analyses the oxide of iron was always mixed with subphosphate of iron, is no proof that such a salt existed in the water: it is merely in consequence of the property which oxide of iron possesses, when precipitated from a solution con-

taining phosphoric acid, of carrying along with it a portion of that acid, of which it cannot afterwards be completely deprived even by the most powerful bases.

The quantity of oxide of manganese was ascertained by dissolving the above 2·514 grammes of carbonate of lime in nitric acid, evaporating the solution completely to dryness, and treating the dry mass with alcohol. A brownish coloured substance remained undissolved; and the oxide of manganese contained in it was thoroughly freed from any adhering nitrate of lime or nitrate of strontian, by being washed first with alcohol, and afterwards with acidulated water. It weighed after ignition 0·004 gramme. The oxide of manganese exists in the water in the state of carbonate: it never forms an ingredient in the sprudelstone, because the carbonate of manganese is almost as soluble in water as the carbonate of magnesia.

According to these several analyses, the solid ingredients in 1000 parts of the Carlsbad water are as follows:

Sulphate of soda	2·58713
Carbonate of soda	1·26237
Chloride of sodium	1·03852
Carbonate of lime	0·30860
Fluate of lime	0·00320
Phosphate of lime	0·00022
Carbonate of strontian	0·00096
Carbonate of magnesia	0·17834
Subphosphate of alumina	0·00032
Carbonate of iron	0·00362
Carbonate of manganese	0·00084
Silica	0·07515*
	5·45927

The excess of 5·45927 over 5·408, the quantity obtained by the direct evaporation of the water, is occasioned by the magnesia, and the metallic oxides being regarded in this estimate as combined with their full proportion of carbonic acid.

I have examined in a similar manner the water from the Mill spring, the New spring, and Theresia's spring, but found in them all, not only the same constituents, but these constituents also in exactly the same proportions, as in the water from the Sprudel; a further confirmation that all the Carlsbad waters proceed from one common main stream, or reservoir.

As it was not improbable that the Carlsbad water might contain a small quantity of potash, I converted a portion of the soluble salts into muriate of soda, and added as much muriate of platinum as was sufficient to form a double salt with the

* Under the silica I have included a small quantity which was separated from the oxide of iron, and from the phosphate of alumina.

soda The solution was then evaporated to dryness by a moderate heat, and the dry mass was treated with alcohol of the specific gravity 0·84. Not a trace of muriate of platinum and potash remained undissolved: the water therefore contained no potash, for that double salt is quite insoluble in alcohol. Potash must, however, on some occasions, constitute an ingredient of the water, for I have detected the fluosilicate of that alkali in several sprudelstones.

Although no circumstances gave occasion to a suspicion that lithia existed in the water, its presence was still possible. To ascertain the point, I mixed a quantity of the soluble salts with a solution of subphosphate of ammonia: the liquid neither became turbid, nor did it yield a precipitate by evaporation. When, in a comparative experiment, this salt was mixed with a solution of lithia, there was deposited during evaporation a crystalline powder, the greater portion of which remained undissolved, on treating the dry saline mass with water. When the salt examined in this manner had not been previously fused in a red heat, it always gave with phosphate of ammonia a slight precipitate, similar to phosphate of lithia; but on examining this substance before the blowpipe, I found that with nitrate of cobalt it fused to a pale red coloured pearl, and that when it was treated on charcoal with carbonate of soda, the latter salt was absorbed, and left an earthy matter behind. Phosphate of lithia fuses with nitrate of cobalt to a blue pearl, and is absorbed by the charcoal at the same instant with the carbonate of soda. This precipitate proceeded therefore from a residue of carbonate of magnesia in the alkaline liquid.

It still remains to make some observations upon the manner in which these different ingredients were combined with one another in the water. Murray first directed the attention of chemists to the fact, that the analysis of a mineral water often gives the ingredients in the state of compounds, totally different from those which existed originally in the water. This is very true; but he overlooked the difference between the results of analysis, and the actual relations of the substances. Berthollet's investigations respecting the action of chemical masses in conjunction with that of the relative affinities, had already, long before, given a satisfactory answer to this question. He has demonstrated that if a number of salts which do not decompose one another according to the usually admitted laws of affinity, be dissolved in water, a decomposition nevertheless ensues to a certain extent; a portion of each acid uniting with a portion of each base, so that combinations are formed between the whole of the substances, individually, which exist in solution. Thus, if caustic soda be mixed with sulphate of potash, a certain quantity of sulphate of soda is formed, and the acid is divided between the bases in such a manner, that the uncombined por-

tions of each correspond. If the soda were previously combined with muriatic acid, the decomposition would be still more extensive, because a portion of the muriatic acid would at the same time unite with the potash. Two salts were originally dissolved in the water, but these constitute four, so long as they remain in solution; if the water be evaporated, the two are again recovered, for the reasons which have been so ably developed by Berthollet.

Should it be asked what quantity of each of these four salts exist in solution? We must allow, that so long as their amount cannot be ascertained by actual analysis, the question must remain unanswered. These quantities depend, in the first place, upon the respective quantities of the two salts originally mixed, and, in the second, upon the relative attractive forces of the acids and bases. The former of these points may be easily ascertained, but we as yet possess no data for a precise determination of the latter. Could we express the relative attractive forces of each individual substance in numbers, in the same manner as we express its specific heat or its specific gravity, it would then become easy to perform this calculation from the results of an ordinary analysis. As yet, however, not one of these relative affinities is so thoroughly understood, that its precise amount can be compared with that of another; and, it is therefore altogether impossible to determine with certainty, from the results of an analysis, to what extent the acids and bases had been combined with one another in the original solution. At present, the utmost we can accomplish, is to state the direct results of an accurate analysis. Theory informs us, that the substances constituting our result are different from those which actually existed in the water; but we should be wrong to associate them with one another in any other manner, because such an arrangement could have for its basis nothing better than uncertain conjecture.

In the Carlsbad water, one of the bases, the soda, preponderates so considerably over the other, that the real constitution of the water must correspond pretty closely with the result of analysis. Nevertheless, we may be certain that the water contains small quantities of sulphate and muriate of lime, as also of sulphate and muriate of magnesia, and a correspondingly larger quantity of carbonate of soda than the analysis indicates; although these salts are gradually decomposed, in proportion as the quantity of water is diminished during evaporation. The substances which the water contains in such extremely minute quantities, must be subject to the same law of mutual decomposition, only the action of the law will in the case of these be much less perceptible.

In stating the result of my analysis, I have given the alkaline carbonates as I found them in the dry salt, obtained by eva-

porating the water: in the water itself, however, they all exist in the state of bicarbonates.

Neither fluate nor phosphate of lime is soluble in water, but their solubility in acids led me to suppose, that, in the Carlsbad water they are held in solution by the uncombined carbonic acid. To prove this, I diffused a quantity of recently prepared and still moist fluate of lime through water, and impregnated the liquid with carbonic acid gas. The filtered liquid, on being heated to ebullition, deposited an exceedingly minute trace of fluate of lime. I now put a quantity of carbonate of soda and fluate of lime into another portion of water, and saturated the mixture with carbonic acid. The solution in this experiment became most distinctly turbid when boiled, and deposited fluate of lime. It is obvious from this, that bicarbonate of soda is the real solvent of the fluate of lime in the Carlsbad water.

Phosphate of lime, both when precipitated by ammonia from its solution in acids, and by lime water from a liquid containing phosphoric acid, dissolves in water impregnated with carbonic acid with much greater facility, and to a much greater extent, than fluate of lime: and I could perceive no difference in this respect, whether the water contained soda or not. Both the phosphate and subphosphate of alumina are soluble to a slight degree in water, and are precipitated by the addition of a considerable quantity of any salt. No phosphate of alumina exists in the sprudelstones; it would appear that carbonic acid is its solvent while in the water. Perhaps, also, the protoxide of iron, in proportion as it becomes peroxidized, shares the acid with the alumina, and renders it insoluble; and, perhaps, the lime may act in the same manner, at the instant when it ceases to be a bicarbonate.

Quantity of Carbonic Acid in the Carlsbad Water.

The want of a mercurial trough, and of the other necessary apparatus, prevented me from ascertaining this point on the spot experimentally; I hoped, however, to have attained my object by less direct means, but, on making the attempt, I encountered greater difficulties than had been at first anticipated. It appeared to me, that if we could determine the nature and relative amount of the gases which stand over the water in the subterraneous reservoir, it would be easy, from the knowledge we possess respecting the solubility of gases, at given temperatures and pressures, to calculate the quantity of carbonic acid in the water which lies in contact with this atmosphere. A small opening which has been made in the vault of the reservoir, in the neighbourhood of the Sprudel, and from which gas and water are discharged alternately, enabled me to collect a sufficient quantity of gas for my purpose. On my return, I let up a determinate quantity of this gas into a glass tube standing over

mercury, and introduced into it a bit of hydrate of potash. It was so completely absorbed, that the minute bubble of air remaining could not be accurately measured, and could not at the utmost have amounted to more than a thousandth part of the original volume. A quantity of gas collected in a similar way at Theresia's spring, left one per cent. of a gas which appeared to be azote, as it was not sensibly absorbed by a solution of sulphuret of potash.

I now calculated the quantity of carbonic acid gas which the water in the reservoir should contain, on the supposition that 100 volumes of it absorb 104 volumes of the gas, at the temperature 164¾°, making allowance at the same time for the additional pressure to which it is subjected, and which may be estimated by the height to which the jet of the Sprudel rises above the surface of the water in the reservoir. The result was, that the disengaged carbonic acid gas, taken at the temperature 32°, should constitute three-fourths of the volume of the water. If we add to this the carbonic acid of the bicarbonates, which by weight constitutes 0·075 per cent. of the water, and at 32° would occupy 0·396 of its volume, it will follow that the water, when boiled, should emit at least $1\frac{1}{10}$ times its volume of carbonic acid gas, measured at the temperature of 32°. But the taste alone of the water is sufficient to convince us that the quantity thus indicated is greatly in excess. By direct experiment, Becher found precisely as much gas in the water as would be requisite to convert the whole of the carbonates into bicarbonates; Klaproth found rather less than this quantity; Reuss found rather more. I am of opinion that the quantity of gas contained in the water when it first issues from the earth, is rather greater than what would convert the carbonates into bicarbonates.

This seeming anomaly is probably occasioned by a circumstance, to which no attention has hitherto been paid in determinations respecting the solubility of gases in water, because it exerts but little influence at the ordinary temperatures. Water, under every temperature and pressure, possesses a determinate tension, and any gas standing over the surface of water, always contains an admixture of its vapour, which in this situation acts in exactly the same manner as a permanently elastic gas. When a mixture of carbonic acid gas, and of the gas (or vapour) of water stands over the surface of water, the interstices of the liquid must contain a portion of this gaseous mixture, that is, both of the carbonic acid gas, and of the gas of water. The apparent absorption by water, therefore, of any pure gas, as for example, carbonic acid gas, in a given temperature and pressure, is in fact the quantity which, in that temperature and pressure, is necessary to maintain the equilibrium between the carbonic acid gas and the gas of water, both

throughout and over the surface of the liquid. Every pure gas which is placed in contact with water becomes instantly a mixed gas in consequence of the evaporation of the liquid, and the proportion of the aqueous to the permanently elastic gas augments with the temperature. Unless this happened, it would be impossible to expel by boiling, a greater quantity of gas from water, than the difference between the augmentations of volume which the elevated temperature induces upon the gas and the water. But ebullition, we know, expels every particle of a gas from water; and for precisely the same reason that a gas when passed through the aqueous solution of another, gradually expels the latter, and finally occupies its place, so does gas continue to be expelled from water in a state of ebullition, until the interstices of the latter become completely occupied by the newly formed vapour. But respecting the capacity of water for its own peculiar gas, we, at present, know nothing: were it known, it would be easy to ascertain by calculation the quantity of carbonic acid which is contained in the Carlsbad water, while confined within its subterraneous reservoir.

The precipitate which always makes its appearance in the Carlsbad water, when kept for some time, consists of silicate of peroxide of iron, subphosphate of peroxide of iron, and subphosphate of alumina, mixed with a substance of organic origin, which is naturally colourless, but which by slow degrees becomes black when exposed to the action of the atmosphere. This substance appears to constitute a very common ingredient in mineral waters of this nature. I have found it, for example, in the sediment deposited by the water of the mineral spring Schiersäuerling, in the neighbourhood of Königswart; and the silica obtained in the analysis of this water is always more or less dark coloured, until the organic substance has been destroyed by ignition. It appears to possess a peculiar affinity for silica, and to associate itself with this earth in preference to any of the other ingredients of the water. The silica, when in combination with it, is almost black before being reduced to a state of dryness; it is then greyish coloured, but darkens again when moistened.

Examination of some Sprudelstones.

The sprudelstone is a radiated crystalline species of limestone, which exhibits no traces of a foliated texture. Its colour is sometimes white and sometimes brown, and not unfrequently alternates in white and brown stripes. The texture varies extremely in different specimens; sometimes it is most decidedly radiated, at other times it is almost compact; and specimens of the latter description are not unfrequently transparent when in thin fragments. Some of the white varieties possess

an uneven fracture, and bear a close resemblance to magnesite [dolomite?] or gurhofite.

Before the blowpipe, the sprudelstone swells somewhat, loses its colour, and either falls to powder of itself, or may be reduced to that state by the slightest pressure. If the experiment be made in a small glass matrass, some water is rendered visible; and the quantity of water disengaged is proportional to the radiated structure of the stone. Now this is a distinctive character of arragonite;* between which and the sprudelstone there is a remarkable similarity in their fibrous texture, in their total want of any foliated structure, in their specific gravity, in the alterations which they undergo when ignited, and in their containing a certain quantity of water, and of carbonate of strontian. The compact sprudelstones contain little or no water; and acquire no tendency to disintegration by being calcined.

1. The following I ascertained to be the composition of two sprudelstones, which approached pretty closely to one another in the nature and relative proportion of their constituents. The first is the incrustation which is deposited upon the exterior surface of the tin vessels mentioned in p. 129. The second is a brown, fibrous, and very compact variety, which is frequently cut into ornaments. Specific gravity 2·863.

Water	1·59		1·40
Carbonate of lime.....	96·47		97·00
Carbonate of strontian.	0·30		0·32
Fluate of lime.....	0·99		0·69
Phosphate of lime	0·06		0·59
Phosphate of alumina..	0·10		
Oxide of iron	0·43		
Oxide of tin	0·06		
Oxide of manganese..	Trace		
	100·00		100·00

2. A white variety, partly granular and partly delicate fibrous in fracture, on being dissolved in muriatic acid, left a semitransparent substance, which was converted into a white powder by desiccation. This substance was fluosilicate of potash; for it was fusible before the blowpipe, sulphuric acid disengaged from it fluosilic acid, and the residue consisted of sulphate of potash. Ammonia threw down from the solution a yellow-coloured pre-

* That this property is not possessed by every variety of fibrous limestone may be easily proved by heating fragments of sattin spar, arragonite, and sprudelstone, in a small glass matrass before the blowpipe. The arragonite, and soon after the sprudelstone, fall to powder; but the sattin spar continues wholly unaltered. The richer the arragonite is in strontian, the speedier is its disintegration.

cipitate, constituting 0·6 of the weight of the stone, and composed of 0·47 fluate of lime, 0·07 of the phosphates of lime and alumina, and 0·06 of oxide of iron. The ammoniacal liquid, on being concentrated, deposited an additional quantity of the fluosilicate of potash, but the difficulty of washing it prevented me from ascertaining its weight.

3. The white compact variety resembling magnesite does not contain a trace of magnesia, agreeing, in this respect, with all the other varieties of the sprudelstone. The carbonate of strontian also, and the earthy fluates and phosphates, exist in it in the usual proportion.

4. A very peculiar variety of sprudelstone, which is formed by the combined action of oxidation and evaporation, was found to be composed of

Carbonate of lime	43·20
Subphosphate of peroxide of iron	1·77
Peroxide of iron	19·35
Carbonate of protoxide of iron	12·13
Phosphate of alumina	0·60
Silica	3·95
Water	9·00
	100·00*

Article XIV.

Astronomical Observations, 1824.
By Col. Beaufoy, FRS.

Bushey Heath, near Stanmore.

Latitude 51° 37′ 44·3″ North. Longitude West in time 1′ 20·93″.

Moon eclipsed.

July 10. Beginning	15h	29′	18″	Mean Time at Bushey.
	15	30	39	Mean Time at Greenwich.

Article XV.

Reply to an erroneous Statement respecting Sir Humphry Davy's Method of defending the Copper Sheeting for Ships' Bottoms.

Since Sir Humphry Davy's paper (see p. 94) was printed, the 32d number of a weekly publication, called the Mechanic's

* The sum of these quantities (correctly copied from the original) is only 90. Should the carbonate of lime be 53·2 ?—*Edit.*

Magazine, has been put into my hands, which contains an article, signed Samuel Deacon, and entitled "Sir Humphry Davy's Remedy for the Decay of Copper Bottoms, not original." The assertion is founded on the following advertisement in "The World" newspaper, of April 16, 1791:—"By the King's patent, *tinned copper* sheets and pipes, manufactured and sold by Charles Wyatt, Birmingham, and at 19, Abchurch-lane, London." These sheets, amongst other advantages, "are particularly recommended *for sheathing of ships*, as possessing all the good properties of copper, with others obviously superior, which the following extract from a report founded on actual experiment, by Dr. Higgins, clearly demonstrates, viz. that this coating of tin powerfully resists the action of salt water, and, by preventing the corrosion of the copper, operates as a preservative of the iron placed contiguous to it."

The best answer to this attack we have given already, by laying Sir Humphry Davy's paper, from the Philosophical Transactions, before our readers, from which it is most obvious, that his views have nothing in common, except their object, with those of the patentee aforesaid. As far as the extract given by his advocate, Mr. Deacon, enables me to judge, it seems that the superiority claimed by Mr. Wyatt consists merely in coating the surface of the copper sheets with some substance less subject to corrosion by sea water than that metal, and his idea was probably borrowed from the common practice of tinning culinary copper vessels,—a practice known to, and adopted by, the Romans.* As Mr. Deacon gives no particulars of the mode of applying or preparing these tinned plates, it is fair to infer that there was nothing peculiar to them in either respect, and all the claim that he can possibly make out to originality is in the application of an old fact to a new purpose.

But it is not on the substitution of tinned copper for plain copper, that Sir Humphry Davy's pretensions to originality rest: it is in the *principle* on which that substitution, or rather an equivalent and, as we shall presently see, a superior process is recommended, that his claims are founded. For the explanation of that principle, I refer the reader to Sir Humphry Davy's paper; but I will ask, did Mr. Wyatt know, that even though nine-tenths of the tin be worn away from a copper saucepan, and the copper exposed, the vessel may still be used with safety? Could he have explained the cause, if he knew the fact? When he prepared his sheets, did he carefully tin the whole surface, or was he aware that if the preservative metal were applied to a comparative speck of it only, it would be equally effectual? Or, lastly, had he the remotest idea that, so applied, it would act as

* Stannum illitum æneis vasis saporem gratiorem facit, et compescit æruginis virus, &c.—(Plin. Hist. Nat. lib. 34, c. 17.)

a preservative at all? If he did know all this, he knew much more than one of the ablest chemists of the day; for Dr. Watson, in the seventh edition of his Essays, published in 1800, insists very strongly on the danger of tinned copper vessels, *in case of abrasion of the tin;* and *so apprehensive was he of the consequences of the minutest portion of copper being uncovered,* that he says that "a new copper vessel, or a copper vessel newly tinned, is more dangerous than after it has been used; because its pores, which the eye cannot distinguish, get filled up with the substances which are boiled in it, and all the sharp edges of the prominent parts become blunted, and are thereby rendered less liable to be abraded." Dr. Watson, therefore, was so far from being aware of the principle on which Sir Humphry Davy's invention is founded, that he obviously was not even aware of the fact alluded to, and the Birmingham patentee was probably not much better informed than the Bishop of Llandaff. At the date of Mr. Wyatt's patent, and for many years after, all the world was ignorant of the principle of action of the defending metal; nor was it developed till the instrument of Volta, in the hands of Davy, furnished the clue; and its present important application is, in fact, an extension of the same train of reasoning that led to his preceding discoveries in electro-chemical science.

It is in the *principle,* therefore, I repeat, that the merit and originality of Sir H. Davy's method is founded, and the importance of the principle is confirmed by a circumstance which would have rendered a mere mechanical covering, like Mr. Wyatt's, useless and abortive. The defended copper is more liable to become foul from the adhesion of barnacles, weeds, &c. than the undefended. Had Mr. Wyatt's tinned sheeting been adopted, it would have been subject to the same pest, nor is it probable that in the then state of chemical science, he could have suggested a remedy for the evil. With the light thrown on the subject by Davy, the antidote is obvious. Barnacles, &c. do not adhere to the undefended copper, because the oxide on its surface poisons them, but the clean metallic surface of the defended copper does them no harm. All that is necessary, therefore, is to weaken the defensive action, by diminishing the extent of defending surface, to such a point as to allow a slight oxidation of the copper, sufficient to repel the animalculæ, but not sufficient to occasion a serious waste of the metal. J. G. C.

Article XVI.

Analyses of Books.

Philosophical Transactions of the Royal Society of London, for 1824. Part I.

Of the papers contained in this part of the Philosophical Transactions, two are given entire in the present number; we purpose to reprint two others, of similar value, in the ensuing numbers of the *Annals;* of three others copious reports have already been presented to the reader: whilst the remainder, being on subjects of Astronomy and Mathematics, cannot usefully be epitomized. We shall, therefore, confine our extracts in this place to the titles of these papers.

I. *The Croonian Lecture.—On the Internal Structure of the Human Brain, when examined in the Microscope, as compared with that of Fishes, Insects, and Worms.* By Sir Everard Home, Bart. VPRS. (See *Annals,* N. S. vii. p. 65.)

II. *Some Observations on the Migration of Birds.* By the late Edward Jenner, MD. FRS. (See ibid. p. 66.)

III. *On the Nature of the Acid and Saline Matters usually existing in the Stomachs of Animals.* By William Prout, MD. FRS. (See present number, p. 117.)

IV. *On the North Polar Distances of the principal Fixed Stars.* By John Brinkley, DD. FRS. &c. Andrew's Professor of Astronomy in the University of Dublin.

V. *On the Figure requisite to maintain the Equilibrium of a Homogeneous Fluid Mass that revolves upon an Axis.* By James Ivory, AM. FRS.

VI. *On the Corrosion of Copper Sheeting by Sea Water, and on Methods of preventing this Effect; and on their Application to Ships of War and other Ships.* By Sir Humphry Davy, Bart. Pres. RS. (See present number, p. 94.)

VII. *A finite and exact Expression for the Refraction of an Atmosphere nearly resembling that of the Earth.* By Thomas Young, MD. For. Sec. RS.

VIII. *The Bakerian Lecture.—On certain Motions produced in fluid Conductors when transmitting the Electric Current.* By J. F. W. Herschel, Esq. FRS. A portion of this Lecture will appear in our next number.

IX. *Experiments and Observations on the Development of Magnetical Properties in Steel and Iron by Percussion. Part II.* By William Scoresby, Jun. FRSE. &c. Communicated by Sir Humphry Davy, Bart. Pres. RS. (See *Annals,* N. S. vii. p. 230.)

X. *On Semi-decussation of the Optic Nerves.* By William Hyde Wollaston, MD. VPRS.

This interesting paper will appear in the next number of the *Annals.*

Article XVII.

Proceedings of Philosophical Societies.

ASTRONOMICAL SOCIETY.

June 11.—The following papers were read :—

1st. On the Variation of the mean Motion of the Comet of Encke produced by the Resistance of an Ether; by M. Massotti. This comet is well known to evince a diminution of its periodic time at each revolution, and the object of this paper was to demonstrate the cause of this effect. Encke himself supposed it was occasioned by an ether diffused through space; but if so, how happens it that the planets also have not been retarded? This the author attempted to show might be the case, although the phænomenon might pass unobserved. He adopts with Encke, the hypothesis of Newton, that the density of this ether diminishes in the inverse ratio of the square of the distance from the sun; consequently that the planet Mercury would be most likely to be affected by it; and by a long series of analytical investigation, assisted by Legendre's tables of elliptic functions, arrives at the result, that this resistance would not produce a greater change in the mean geocentric longitude of Mercury, than 31·2″ in the course of a century. Hence he concludes that the comet may have such a resistance from an ether, as will be sufficient to account for the difference between the calculus and the observations, and yet that the planets shall not hitherto have manifested the least effect of such a medium.

2d. On a new Astronomical Instrument called the Differential Sextant; by Benjamin Gompertz, Esq. FRS.—This paper was a further and more particular description of the construction and application of the instrument before invented by Mr. Gompertz, and partially described in his paper on Astronomical Instruments read before the Society on the 11th of January, 1822. In this instrument, the index reflector is susceptible of motion on one end of the index as on a centre, being the same as that on which the index itself turns, so that the reflector may be set to make any angle at pleasure with the index; the whole being permitted to move, as a bent lever about the centre. The horizon glass also is capable of being adjusted and fixed at different angles to the fixed arm. The object proposed by Mr. Gompertz in this contrivance is to measure the *difference* of angular distances in any two celestial phænomena, occasioned by those varying circumstances which produce small changes; such as refraction, parallax, aberration, &c.: and the paper concluded with some appropriate hints as to the best manner of applying the instrument to these purposes.

3d. An Account of an Occultation of the *Georgium Sidus* by the Moon, which will take place on the 6th of August next; by Francis Baily, Esq. FRS. and V. Pres. Ast. Soc.—Mr. Baily begged to call the attention of the Society to this interesting phænomenon which has never yet been seen, as no occultation has occurred since the discovery of the planet. The occultation will occur within a very few minutes after the moon has passed the meridian; insomuch that those persons possessing a transit instrument will see the planet in the field of view when the moon's centre is on the meridian. This notice was accompanied by a diagram, showing that the planet would enter the western or dark limb of the moon at about half way between the moon's outer and the upper or northern part of her disk. There will be sufficient time to observe the occultation of the planet after the transit of the moon. This interesting phænomenon will no doubt attract the notice of every practical astronomer.

This being the last meeting of the Society's present session, an adjournment took place until the 12th of November next.

Article XVIII.

SCIENTIFIC NOTICES.

Chemistry.

1. *Cystic Oxide.* Communicated in a Letter from Dr. Noehden to Mr. Children.

MY DEAR SIR,

In a letter which I lately received from my friend, Prof. Stromeyer, he communicates some chemical information, which may, perhaps, interest you, and which, therefore, I take a pleasure in imparting. "He had, some time ago," he says, "the great satisfaction of discovering in gravel from the human body Dr. Wollaston's *cystic oxide;* and afterwards in the urine of the same patient, who is afflicted with the stone, the same substance in considerable quantity. In this urine, the *uric acid* was almost totally wanting, nor was the *urea* found in it in natural quantity. As the cystic oxide has hitherto not been found in any *human concretions* any where but in England, and has as yet been *nowhere* observed in the *urine itself*, I wish you," he says, "if you should see Dr. Wollaston, to mention this to him, at the same time respectfully remembering me to him. I have no doubt this intelligence will interest him. I mean shortly to publish a brief notice upon the subject. Last year, M. Lassaigne, of Paris, also found *cystic oxide* in a stone from the bladder of a dog."

If you wish to make any use of this information, you are welcome to do so.

I am, my dear Sir, yours sincerely, G. H. Noehden.

2. *Note on a Contradiction in Thomson's System of Chemistry respecting Phosphuretted Hydrogen Gas.* By M. Vauquelin.*

At p. 273 of Thomson's System of Chemistry, article "Phosphuretted Hydrogen," we read as follows: "When electric sparks are passed through this gas for some time, the phosphorus is deposited, and pure hydrogen gas remains. But the volume of the gas is not altered by this process. Hence it follows, that phosphuretted hydrogen gas consists of hydrogen gas, holding a quantity of phosphorus in solution. This quantity is discovered by subtracting the specific gravity of hydrogen gas from that of phosphuretted hydrogen." Further on, p. 275, it is said that bihydroguret of phosphorus (proto-phosphuretted hydrogen) "may be procured by exposing phosphuretted hydrogen to the direct rays of the sun. A quantity of phosphorus is deposited, and the gas is changed into *bihydroguret of phosphorus.*"

"When sulphur is sublimed in this gas," continues Dr. Thomson, "the volume is doubled, and two volumes of sulphuretted hydrogen gas are formed. When potassium is heated in it, the volume is also doubled. Hence it is obvious that it (proto-phosphuretted hydrogen gas) is a compound of two volumes of hydrogen gas, united with the same quantity of phosphorus that exists in a volume of phosphuretted hydrogen gas, and condensed into one volume."

Here is a manifest contradiction: in fact, if phosphuretted hydrogen gas (perposphuretted hydrogen) be a solution of phosphorus in the hydrogen without condensation, and if this gas be converted by the luminous rays, or by electricity, into protophosphuretted hydrogen, without any change of volume, it is evident that the latter is also a solution of phosphorus in hydrogen without condensation, and that the only difference between the two gases consists in the quantity of phosphorus.

If the second part of Dr. Thomson's reasoning be true, the phosphuretted hydrogen gas must be reduced to half its volume by being converted into protophosphuretted hydrogen; but, according to Thomson himself, that is not the case. It would probably be the first instance in which hydrogen has been found to be condensed, on abandoning a solid which it had held in solution: the contrary more frequently occurs.

It was important, however, to ascertain if the volume of protophosphuretted hydrogen gas be doubled by heating sulphur in it; for, as it is proved by accurate experiments, that sulphuretted hydrogen contains an equal volume of hydrogen, if the volume of protophosphuret be actually doubled by the process, it must contain two volumes of hydrogen condensed into one.

* From the Annales de Chimie.

That this is not the case, M. Vauquelin proceeds to demonstrate by five experiments.

In the first, 100 measures of perphosphuretted hydrogen gas were decomposed by exposure to the sun's rays for some days; phosphorus was deposited, but the volume of the gas was not sensibly diminished.

In this experiment, M. Vauquelin observed, that the decomposition was not complete; for a portion of the gas being suffered to escape some time afterwards, it inflamed, and deposited phosphorus. He observed also that the phosphorus is not deposited during exposure to the sun, but as the gas cools at night.

One hundred measures of perphosphuretted hydrogen increased about 1-10th in volume by being heated with sulphur, and were converted into sulphuretted hydrogen gas. 100 measures of protophosphuretted hydrogen, similarly treated, were also converted into sulphuretted hydrogen without any sensible change of volume.

In his fourth and fifth experiments, M. Vauquelin found that perphosphuretted hydrogen gas is more speedily decomposed, even in the dark over distilled water, both at common temperatures, and when artificially cooled, than by exposure to the direct rays of the sun; the decomposition appears also to be more complete. In one experiment, 125 measures lost 1-25th of their volume. The decomposition cannot be owing to air contained in the water, for the volume of the gas is not sensibly diminished; besides it is slightly soluble in water.

M. Vauquelin concludes, therefore, that phosphuretted and protophosphuretted hydrogen gases consist simply of phosphorus dissolved in hydrogen without condensation; that each gas contains a volume of hydrogen equal to its own, and that the only difference between them is in the proportion of phosphorus which they respectively contain.

3. *Supposed New Metal, Taschium.*

A description of a new metal, with an accompanying specimen, has been sent to the President of the Royal Society.

The metal has received the name of Taschium, from the mine of Taschio in which it was found.

The specimen sent was said to be silver containing the new metal, the two metals having been separated by amalgamation, and the mercury afterwards driven off. On dissolving the button in pure nitric acid, it was stated that the Taschium would remain as a black powder.

The Taschium was described as being combustible with a bluish flame, a peculiar smell, and dissipation of the products. Amalgamating with mercury, and in that way being separated from its ores. Not soluble in any single acid, but soluble in nitro-muriatic acid. If previously boiled with potash, then

soluble in muriatic acid, the solution being precipitated by water. Its solution giving, with prussiate of potash, a blue precipitate brighter even than that with solution of iron, but not precipitating with tincture of galls.

The button was therefore dissolved in nitric acid, which left a blackish powder in small quantity, and also some grains of siliceous sand. The powder was well washed, and then being heated on platina foil in the flame of a spirit lamp, did not burn or volatilize, but became of a deep red colour. Muriatic acid being added to another portion of the washed powder, and a gentle heat applied, dissolved by far the greater part of it, forming a red solution which being evaporated till the excess of acid was driven off, and then tested, gave a blue precipitate with prussiate of a potash, black with tincture of galls, and a reddish brown with ammonia.

On evaporating to dryness it left muriate of iron. Nitro-muriatic acid being made to act on the minute portion of powder yet remaining, dissolved very nearly the whole of it, leaving a small trace of silica, and producing a solution similar to the former. Hence the Taschium in this button of silver was nothing else than iron, and from the presence of siliceous sand it may be supposed to have been introduced into the button through the inaccuracy of the preparatory manipulations. M. F.—(Journal of Science.)

4. *Chalybeate Preparations of the London Pharmacopœia.*

The following table exhibits what quantity of each preparation contains one grain of oxide of iron:

One gr. of oxide is contained in		gr. 3·8	Ferri Sulphas
Do.	do.	66·0	—— Subcarbonas
Do.	do.	1·2	Ferrum ammoniatum
Do.	do.	5·0	——— Tartarizatum
Do.	do.	20·0	Pilulæ Ferri compositæ
Do.	do.	♏xxx	Liquor Ferri Alkalini
Do.	do.	ʒiss	Mistura Ferri composita
Do.	do.	ʒiij	Tinctura Ferri Ammoniati
Do.	do.	♏xiv	———————— Muriatis
Do.	do.	ʒj	Vinum Ferri (R. P.)

5. *Zirconia in Black Pepper.*

The Journal de Pharmacie for May last contains the following notice on the above subject:—" M. Dublanc, jun. read a notice of a work of M. Meli de Ravennes, relating to the discovery of zirconia in black pepper, by M. le Comte Paoli de Milan."

6. *On the Use of Nitrous Oxide in Eudiometry.*

Multiplied experiments prove atmospheric air to contain $\frac{21}{100}$ of oxygen, yet nitrous gas sometimes indicates less, sometimes

more, than that quantity. Even in the hands of the late Mr. Cavendish, it seems to have given capricious results, sometimes producing a diminution, in a mixture of 125 nitrous gas and 100 air, of 115 parts, and at others of 121·2 parts.* By Gay-Lussac's method of applying the test, however, the results are constant. It consists, as is well known, in introducing a known bulk of air into a wide vessel over water, and afterwards adding an equal bulk of nitrous gas; after standing one minute, the residuum is transferred to a graduated tube, and the diminution of volume noted. This divided by 4, gives the quantity of oxygen.

Mr. Dana remarks, that the true theory of the effect thus produced has never been explained, and he offers the following ingenious solution:

"It is perfectly well established, that

Vols. oxygen.	Vols. nitrous gas.	
100	unite with 400·00	and form hyponitrous acid
100	200·00	nitrous acid, and
100	133·33	nitric acid.

"When we mix, therefore, 100 parts of atmospheric air with 100 parts of nitrous gas, the diminution in volume, if nitric acid only be formed, should be 49 parts; if nitrous acid only, 63 parts; if hyponitrous acid only, 105 parts. But experiment teaches us that the diminution of volume is actually 84 parts, and that all the oxygen disappears; now this degree of diminution can be produced only by the formation and absorption of *hyponitrous acid* and of *nitrous acid;* and the oxygen present is *equally* divided between them, viz.

Vols. oxygen.	Vols. nitrous gas.	
50	unite with 200	and form hyponitrous acid
50	100	nitrous acid
100	300	

"Or, as in the analysis of the air, which contains 21 per cent. of oxygen, and the diminution amounts to 84 parts when 100 each of air and nitrous gas are employed,

	Vols.
One-half its oxygen, equal.	10·5
Unites, to form hyponitrous acid, with nitrous gas	42·0
The remainder of the oxygen.	10·5
To form nitrous acid, unites with nitrous gas	21·0
All of which are condensed, equal	84·0

* "The greatest diminution was 110, the least 106·8; the mean 108·4." Thomson's Chemistry, vol. iii. p. 166.

"The theory here proposed perfectly corresponds with the fact, and the experiment confirms the existence of hyponitrous acid; the degree of diminution cannot, I apprehend, be explained on any other supposition than that now made. The fact, that the water, which absorbs the red vapours, produces *nitrites*, is no proof that *nitrous* acid alone is formed; we know very little about the *nitrites;* but it is very easy to conceive, from the relations of *nitrous* and *hyponitrous* acids, that in concentrating a solution containing a mixture of salts, having these acids in their composition, the whole may pass to the state of *nitrites* by the agency of air, heat, and moisture." *Dana.*—(American Journal of Science.)

We are sorry that so ingenious a paper as that from which we have made the preceding extract, should be sullied by the remark respecting Dr. Ure (we beg to be excused quoting it), which occurs at p. 340. It was wholly uncalled for, and the author has most unnecessarily gone out of his way to introduce it.—J. G. C.

7. *Tartarized Antimony.*

Dr. Gobel has given the following as the results of his analysis of this salt:

Protoxide of antimony	42·60
Tartaric acid	45·00
Potash	9·80
Water	3·75
	101·15

Its atomic constitution he considers to be:

2 atoms = 2 × 48 =	96·0	Protox. of antimony	= 1 at. subprotartrate of antim.
+ 1 atom =	69·8	Tartaric acid	
½ atom =	22·5	Potash	= ½ atom of neutral tartrate of potash.
+ ½ atom =	34·9	Tartaric acid	
+ 1 atom =	8·5	Water	

which would give

Protoxide of antimony	41·4
Potash	9·7
Tartaric acid	45·1
Water	3·6
	99·8

(Schweigger's Journal.)

8. *Inflammation of Sulphuretted Hydrogen by Nitric Acid.*

When a few drops of fuming nitric acid are put into a flask filled with sulphuretted hydrogen, the hydrogen is oxidized by

the nitric acid, and the sulphur is disengaged in a solid form. If the flask be closed with the finger, so that the gas which becomes heated cannot escape, its temperature is raised so much as to produce combustion with a beautiful flame, and a slight detonation, which forces the finger from the mouth of the flask. This experiment may be made without the least danger, with a flask containing four or five cubical inches of gas. *Berzelius.*—(Journal of Science.)

9. *Urinary Calculus.*

M. Laugier has lately examined a calculus taken from a young man of 22 years of age. Although this calculus is formed of substances which are frequently met with in this sort of concretions, yet its peculiar appearance, friability, and the proportions of the elements which it contains, induced M. Laugier to publish an account of some practical observations to which it gave rise.

The calculus was of a brownish colour, soft, and friable, and could be taken from the bladder only in pieces. By exposure to the air it became dry, and owing to the loss of moisture, it became of a browner colour.

By examining the calculus with potash, acids, and water, nearly similar results were obtained, but the method recommended to be adopted is the following :—Ten parts of the calculus reduced to powder were heated to the boiling point in an ounce of distilled water; the clear solution was poured off, and the ebullition being twice repeated with a like quantity of water, the solutions were mixed. The insoluble portion was brown, and weighed three parts and a half.

The solution was of a pale-yellow colour, and when hot reddened litmus paper strongly, but not when cold; there were, however, deposited at the bottom of the vessels a great number of small brilliant plates, which were evidently lithic acid; when dried, they weighed one part.

The solution evaporated by a gentle heat gave a white, pearly, laminated residuum; it weighed $4\frac{1}{2}$ parts; did not redden litmus paper, and on the addition of potash, much ammonia was evolved, and it continued till the whole of the matter was dissolved.

The alkaline solution, supersaturated with muriatic acid, gave 2 parts of lithic acid; from this it is to be concluded that the pearly matter obtained by evaporation was lithate of ammonia; there was also a little phosphate of ammonia.

The $3\frac{1}{2}$ parts of insoluble residuum were heated in muriatic acid, which took up $1\frac{1}{2}$ part of oxalate of lime, and this was separated by ammonia; the 2 parts insoluble in the acid appeared to be only animal matter; when burnt, it left only carbonate of lime, and no trace of phosphate of lime; but as the burnt residuum of the entire calculus gave, in a previous experiment, half a part

of phosphate of lime, it is to be concluded that the phosphoric acid is combined with ammonia, and not with lime, and in fact the presence of this compound was determined.

Ten parts of the calculus, therefore, consist of

Substances soluble in Water.

Lithic acid	1 part
Lithate of ammonia	4
Phosphate of ammonia	$\frac{1}{2}$

Substances insoluble in Water.

Oxalate of lime	$1\frac{1}{2}$
Animal matter	2
Loss and moisture	1
	10

10. *Odour of Hydrogen Gas extraneous, Inodorous Hydrogen Gas.*

When hydrogen gas, obtained from a mixture of iron filings and diluted sulphuric acid, is passed through pure alcohol, the hydrogen loses its odour in a great measure; and if water be added to the alcohol it becomes milky; if enclosed in a flask and left for some days, an odorous volatile oil is deposited, which was contained in the gas, and which contributed to its well-known odour.

Perfectly inodorous hydrogen gas may be obtained by putting an amalgam of potassium and mercury into pure distilled water, but if an acid or muriate of ammonia be added to the water, which accelerates the developement of the gas, it gives it the same odour as that remarked in the solution of zinc by weak sulphuric acid. This odour, therefore, does not belong to the hydrogen gas, but is given to it by impurities. *Berzelius.*—(Journal of Science.)

11. *Iodine and Phosphorus.*

" Thenard asserts, that in the union of iodine and phosphorus, not only caloric, but light, is extricated. But Sir H. Davy states that no light is evolved in this process. Repeated experiments have convinced me of the accuracy of the observation of the British chemist; but it is only justice to M. Thenard to state, that in the action between these substances, the evolution of light, as well as of caloric, may be shown, according to the mode of making the experiment. If a small piece of dry phosphorus be dropped into a test-tube, and a quantity of iodine, in its usual scaly form, sufficient to *cover* the phosphorus, be quickly added, an immediate action ensues; the tube becomes hot; fumes of iodine are disengaged, and a deep violet-brown liquid is formed, *without the evolution of light*, even when the experiment is made in a darkened room. But if the proportion

of the phosphorus to the iodine be large, and the latter insufficient to cover the former, the action is accompanied by a momentary flash, which I attribute to the combustion of the uncovered portion of the phosphorus in the scanty portion of atmospheric air in the tube. By varying the proportions of the two substances, I can produce the union with or without the extrication of light at pleasure." *Letter from Dr. Traill to Prof. Jameson.*—(Edin. Phil. Journ.)

Mineralogy.

12. *New Ore of Lead.*

A native compound of chloride and oxide of lead has been lately analyzed by Berzelius. He found it forming part of a specimen ticketted lead spar, from Mendip, near Churchhill, in Somersetshire, in the collection of lead ores belonging to the Royal Academy of Sciences of Stockholm. The specimen itself consists chiefly of carbonate of lead; but it contains two portions of a yellower colour than the rest, which attracted in a peculiar manner his attention. On examining them by the blowpipe, one of these proved to be molybdate of lead; the other, which constitutes the mineral in question, afforded decisive indications of the presence of muriatic acid.

The new mineral has a pale straw-yellow colour, is easily frangible, and cleaves with a foliated fracture in two directions. The cleavage planes meet under an angle of between 102° and 103°. Before the blowpipe it decrepitates slightly, and is easily melted: the fused globule, when cold, has a deeper yellow colour than the original mineral. On charcoal it is reduced to metallic lead, and at the same time emits fumes of muriatic acid; also with peroxide of copper, and salt of phosphorus, it imparts to the flame the intense blue colour which characterizes muriatic acid. Dilute nitric acid dissolves it with slight effervescence, and if several fragments taken from different parts of the specimen be thrown into the acid at the same moment, the effervescence occasioned by them may be observed to be unequal.

100 parts of it were found to be composed of

Oxide of lead	90·13
Muriatic acid*	6·84
Carbonic acid	1·03
Water	0·54
Silica	1 46
	100·00

* That is, muriatic acid, according to the old theory of its constitution; not *hydrochloric acid.*

The carbonate of lead is undoubtedly an accidental admixture, as its proportion, on a repetition of the analysis, was found to vary in different parts of the mineral, being least abundant in the centre, and increasing in quantity towards the edges, where the mass is incorporated with the carbonate of lead which constitutes, as it were, its matrix.

He considers the proximate ingredients of the portion, whose analysis we have stated above, to have been

Chloride of lead.	34·63	 1 atom
Oxide of lead.	55·82	 2 atoms
Carbonate of lead	7·55	
Silica	1·46	
Water.	0·54	
	100·00	

This mineral differs from the horn lead analyzed by Klaproth and Chenevix, which possesses a rectangular cleavage, and consists, as has been demonstrated pretty decisively by Berzelius (Afh. i Fysik, Kemi och Min. iv. 125), of an atom of chloride of lead united to an atom of carbonate of lead. It differs also from the ordinary artificial submuriate, which is composed of 1 atom of chloride of lead and 3 atoms of oxide of lead.—(Kongl. Vet. Acad. Handl. 1823, St. 1.)

13. *Mountain Tallow.*

Specimens of this mineral substance were lately found in a bog on the borders of Loch Fyne. This curious mineral was first observed by some peasants on the coast of Finland in 1736; afterwards it was found in one of the Swedish lakes. M. Herman, physician at Strasburgh, observed a similar substance in the water of a fountain near that city; and Prof. Jameson met with it in this country. It has the colour and feel of tallow, and is tasteless. The following notice in regard to it was sent to us:—It melts at 118°, and boils at 290°; when melted, it is transparent and colourless; on cooling, becomes opaque and white, though not so much so as at first. It is insoluble in water, but soluble in alcohol, oil of turpentine, olive oil, and naphtha, while these liquids are hot, but it is precipitated again when they cool. Its specific gravity in the natural state of it, is 0·6078; but the tallow is full of air-bubbles, and, after fusion, which disengages the air, the specific gravity is 0·983, which is rather higher than that of tallow. It does not combine with alkalies, nor form soap. Thus it differs from every class of bodies known; from the fixed oils in not forming soap; from the volatile oils and bitumens, in being tasteless and destitute of smell. Its volatility and combustibility are equal to those of any volatile oil or naphtha.—(Edin. Phil. Jour.)

14. *Rare Minerals found in the Vicinity of Edinburgh.*

Within these few months beautiful specimens of deeply-coloured prehnite have been found in Salisbury Craigs. In several of these, the prehnite was associated with that kind of *datolite* described under the name *Humboldite* by Mr. Levy. In the basaltic rock of the Castle Hill, small but beautiful specimens of radiated *Wollastonite* have been found. Many years ago, fine specimens were got. The same mineral occurs occasionally in h greenstone of Salisbury Craigs.—(Edin. Phil. Journ.)

15. *Discovery of Selenium in the Volcanic Rocks of Lipari.*

Dr. Turner has just sent to us the following interesting notice, the substance of which was communicated to him by Prof. Stromeyer. "Prof. Stromeyer has lately discovered selenium under two different forms, one of which is altogether new. On diluting some fuming sulphuric acid, such as is made at Nordhausen from the sulphate of iron, he observed that a solid matter separated from the diluted acid, which, on examination, proved to be selenium. One pound of the acid gave on dilution about a grain of selenium. This substance has already been detected in some of the Bohemian sulphuric acid; and it is supposed that the acid in question had been prepared in Bohemia. The second source of selenium is in the volcanic productions of the Lipari Isles, among which Prof. Stromeyer has lately discovered a native sulphuret of selenium. He has mentioned neither the mineralogical character of the new mineral, nor given an account of his chemical examination of it; but I hope soon to obtain from the Professor more full information on the subject; and shall then have great pleasure in communicating it to you. It appears probable from these circumstances, that selenium is a more common production of nature than is generally supposed; and it may be anticipated that it will frequently be found, whenever the attention of chemists and mineralogists in general shall be directed to the subject."—(Edin. Phil. Jour.)

Miscellaneous.

16. *Light and Heat from terrestrial Sources.*

Mr. B. Powell, FRS. has, during the last winter, been engaged in a series of experiments on the light and heat emitted from incandescent and burning bodies, in extension of those of MM. Leslie, de la Roche, &c. The principal question investigated is one with regard to the nature of the heating agents, which very naturally arises from the results of the experiments just alluded to:—viz. whether, of the effect from a luminous hot body, the part intercepted by a glass screen is of the same nature as, or different from, the part transmitted, (independently of the heat acquired and radiated again by the screen). The result of

various experiments conducted upon different principles was, that *the two are essentially distinct.* The part of the effect *intercepted* by glass being shown to have a greater relation to the *texture* of the surface on which it acts, and the part *transmitted* to the darkness *of colour.*

17. *Explosive Engine.*

An engine of a very remarkable kind is, we understand, about to be brought into public notice, which, if it answer the high expectation of its inventor, may ultimately supersede the use of the steam-engine. The patents for England and Scotland are, we believe, both completed, so that we may expect soon to hear the particular details of its construction.

At the lower end of a small cylinder is placed a minute apparatus for producing oil gas. As the gas is generated, it elevates a piston so as to admit as much atmospheric air as, when combined with the oil gas, would render the mixture explosive. When the piston has reached this height the gas is exploded, and the mechanical force of the explosion is employed to drive machinery. Experiments have, we understand, been actually made with this power, which was employed to force up water to a considerable height.

Our readers will no doubt be reminded by this brief notice, of the ingenious invention of the Rev. Mr. Cecil, by which the power is obtained by taking advantage of the vacuum created by the explosion of a mixture of hydrogen and common air.—(Cambridge Transactions, vol. i. part 2.) Mr. Cecil suggested in his paper that the expansive force of the explosion might also be employed; but his machine was not founded on this principle.—(Edin. Jour. of Science.)

18. *Electricity produced by Congelation of Water.*

When water is frozen rapidly in a leyden jar, the outside coating not being insulated, the jar receives a feeble electrical charge, the inside being positive, the outside negative. If this ice be rapidly thawed, an inverse result is obtained, the interior becomes negative, and the outside positive. *Grothus.*—(Jour. of Science.)

Article XIX.

NEW SCIENTIFIC BOOKS.

PREPARING FOR PUBLICATION.

The History of Mollusca, containing a Description of all the Species of Recent and Fossil Shells. By J. E. Gray, MGS. This work will be published in Parts, each forming a complete work, illustrated with figures of all the new species, and furnished with Indices, and a geological list of the fossils.

JUST PUBLISHED.

Meteorological Essays and Observations. By J. Frederick Daniell, FRS. With Plates. 8vo. 16*s.*

Elements of Phrenology. By George Combe, President of the Phrenological Society. With Plates. 4*s.*

A Descriptive History of the Steam-Engine. By Robert Stuart, Esq. Civil Engineer. Illustrated by Engravings of 47 Steam-Engines. 8vo. 8*s.*

Phillips's Flora Historica. 2 vols. 24*s.*

Parkes's Chemical Catechism. Enlarged Edition. 14*s.*

Bland's Hydrostatics. 1 vol. 12*s.*

A General Index to the first 19 vols. of the Edinburgh Medical Journal. 8vo. 16*s.*

Article XX.

NEW PATENTS.

J. Wells, Manchester, silk and cotton manufacturer, for his machine for dressing, stiffening, and drying cotton and linen warps, or any other warps that may require it, at the same time the loom is working.—May 25.

J. Holland, Fence House, Aston, York, shoemaker, for certain improvements in the manufacture of boots and shoes.—May 31.

J. Heathcoat, Tiverton, Devon, lace manufacturer, for improvements in the methods of preparing and manufacturing silk for weaving and other purposes.—June 15.

W. A. Jurup, Middlewich, Chester, salt proprietor, and W. Court, Esq. Manor Hall, Chester, for their improved method of manufacturing salt.—June 15.

R. Hooton, of the Aqueduct Iron Works, Birmingham, for certain improvements in manufacturing wrought iron.—June 15.

W. Harwood Horrocks, Stockport, Chester, cotton manufacturer, for his new apparatus, giving tension to the warp in looms.—June 15.

R. Garbutt, of the town of Kingston upon Hull, merchant, for his apparatus for the more convenient filing of papers and other articles, and protecting the same from dust or damage, including improvements on the files in common use.—June 15.

W. Harrington, Esq. Crosshaven, Cork, for his improved raft for transporting timber.—June 15.

C. Chubb, Portsea, Southampton, ironmonger, for his improvements in the construction of locks.—June 15.

B. A. Day, Birmingham, Warwick, fire-screen maker, for certain improvements in the manufacturing of drawer, door, and lock knobs, and knobs of every description.—June 15.

J. M'Curdy, Snow-hill, for an improvement in the method of generating steam.—June 15.

P. Taylor, City-road, engineer, for certain improvements in apparatus for producing gas from various substances.—June 15.

Article XXI.

METEOROLOGICAL TABLE.

1824.	Wind.	Barometer. Max.	Barometer. Min.	Thermometer. Max.	Thermometer. Min.	Evap.	Rain.
6th Mon.							
June 1	N	30·40	30·23	76	45	—	
2	Var.	30·43	30·38	72	49	—	
3	N E	30·43	30·43	62	48	—	
4	N E	30·43	30·34	72	45	—	
5	N E	30·34	30·30	62	50	—	
6	N	30·30	30·26	79	51	—	
7	N	30·26	30·22	85	49	—	
8	E	30·22	30·13	81	46	·81	
9	N E	30·13	30·04	78	51	—	20
10	N E	30·19	30·04	56	44	—	46
11	N E	30·28	30·19	64	34	—	
12	N	30·29	30·21	67	34	—	
13	S	30·21	29·62	66	46	—	84
14	S	29·62	29·39	64	46	—	14
15	S E	29·66	29·40	62	42	—	—
16	S E	29·87	29·40	66	42	—	27
17	N E	30·13	29·87	63	39	—	
18	N	30·13	29·88	72	44	·92	
19	S	29·88	29·59	66	54	—	15
20	S	29·60	29·59	62	53	—	25
21	W	29·69	29·60	72	46	—	
22	S W	29·68	29·54	74	51	—	05
23	E	29·54	29·51	63	51	—	1·08
24	N	29·80	29·54	62	51	—	22
25	N W	30·11	29·80	64	49	—	—
26	N W	30·12	30·11	74	52	—	
27	S E	30·12	30·03	72	54	·88	
28	S W	30·03	29·83	78	52	—	—
29	S	29·96	29·83	79	50	—	—
30	S W	29·97	29·95	73	50	·28	01
		30·43	29·39	85	34	2·89	3·67

The observations in each line of the table apply to a period of twenty-four hours, beginning at 9 A. M. on the day indicated in the first column. A dash denotes that the result is included in the next following observation.

REMARKS.

Sixth Month.—1, 2. Fine. 3. Overcast. 4. Fine and overcast. 5. Fine. 6. Fine: a *Stratus* on the marshes at night. 7. Fine: sultry. 8. Sultry. 9. Fine. 10. Rainy day. 11, 12. Fine. 13. Rainy night. 14. Showery. 15. Cloudy. 16. Fine: rainy night. 17, 18. Fine. 19, 20. Rainy. 21, 22. Fine. 23. Very rainy. 24. Rainy. 25. Cloudy. 26. Cloudy. 27. Fine. 28. Cloudy. 29, 30. Fine.

RESULTS.

Winds: N, 6; NE, 7; E, 2; SE, 3; S, 5; SW, 3; W, 1; NW, 2; Var. 1.

Barometer: Mean height

For the month	29·984 inches.
For the lunar period, ending the 18th	30·152
For 13 days, ending the 4th (moon north)	30·311
For 14 days, ending the 18th (moon south)	30·020

Thermometer: Mean height

For the month	58·400°
For the lunar period	55·810
For 31 days, the sun in Gemini	56·000

Evaporation	2·89 in.
Rain	3·67

Laboratory, Stratford, Seventh Month, 22, 1824. R. HOWARD.

ANNALS

OF

PHILOSOPHY.

SEPTEMBER, 1824.

Article I.

Biographical Sketch of the late Rev. John Josias Conybeare, MA. MGS. formerly Professor of Poetry in the University of Oxford.

That portion of society, to the members of which intellectual pursuits, in their various orders and degrees, form the chief occupation and zest of life, may be subdivided into two classes: those who are principally interested in the contemplation and study of the works of the Creator forming the one; and those who are devoted to the history and investigation of the works of man, constituting the other: the forms of knowledge to which the pursuits of the first class give birth, and which, subsequently, by forming at once the foundations and the instruments for their own extension, afford means for the continuance of those pursuits, are the mathematical and physical sciences; whilst the various species of general literature and of criticism, whether relating to the efforts of the intellect and the imagination as embodied in language, or in the productions of the Fine Arts, together with Archæology, or the science of Antiquities, which is more or less connected with them all, are the objects of attention and inquiry with the second class of society to which we allude.

Now from a period not long subsequent to the rise of the inductive philosophy of which Bacon was the founder, there has existed a prejudice (and it is not yet extinct), that an almost total neglect of the former objects of research, is necessary to success with the latter;—and *vice versâ*:—that the study of the laws of nature is incompatible with the elegant pursuits of cultivated taste; and the investigation of the rules of criticism, and of the language, the polity, and the arts of former ages, inconsistent with the development of natural phænomena.

This prejudice has probably arisen, on the one hand, from the circumstance that the restorers of letters in Europe were for the most part remarkably ignorant of the objects of science, and also deeply imbued with the perversions of reason miscalled the Aristotelian philosophy; and from the consequent disregard in which they and their pursuits were held by the new race of philosophical inquirers, on the other. It has certainly been fostered, likewise, by the mutual disesteem of each other's researches which has been manifested by either party; and though practical contradictions of the principle might have been found in every age, yet little or no inquiry appears to have been instituted into the grounds of the supposition in other cases; and it has been received, to a considerable extent, as an axiom in the history of the human mind.

The intellectual character of the subject of our present memoir appears to have been one of those which have disproved this idea; and the consideration of it has led us into the foregoing reflections. Theological learning, with the various branches of knowledge necessary to its successful prosecution, and the ancient literature of his country, seem to have been his chief pursuits; whilst the scientific researches which formed his amusements, though not extensive, were conducted with the characteristic precision of the modern schools of science. He may be considered, perhaps, in some measure, as a member of that School of Geology, which, to use the language of a near relation, himself one of its distinguished ornaments, "has afforded a striking and satisfactory proof in opposition to the misrepresentations of shallow sciolists, that the institutions of academical education are far from unfavourable to the cultivation of the physical sciences."

The readers of the *Annals*, however, are already acquainted, to a considerable extent, with Mr. Conybeare's attainments; for since the commencement of the present series, he was a frequent contributor to our pages; and it is primarily on this account that we have been induced to draw up the present sketch of his life and labours; both as a mark of attention to our readers, and as a tribute of gratitude to the memory of a kind friend. For part of the materials employed, we are indebted to the urbanity of the Rev. W. D. Conybeare, FRS. and of Henry Ellis, Esq. Sec. SA.: a notice published in the Bath and Cheltenham Gazette, by the Venerable Dr. Moysey, Archdeacon of Bath, has furnished us with others; whilst the perusal of his communications to the Archæologia and other literary collections, has enabled us, in some degree, to judge of the extent of his varied acquirements.

John Josias Conybeare was born in June, 1779, and was the son of William Conybeare, DD. Rector of St. Botolph, Bishop-

gate; and the grandson of Dr. John Conybeare, Dean of Christ Church, Oxford, and afterwards Bishop of Bristol. He was educated at Westminster School, and in the year 1793, having, throughout the examination which precedes such admission, distinguished himself in a most eminent manner, so as to have been constantly at the head of those who stood out, was admitted, at the head of his election, a scholar of the College. The reputation for abilities and scholarship which he thus established, had been anticipated, in consequence of the distinguished talent shown in his school exercises; and it was afterwards supported, whilst he continued at Westminster, in such a manner, as to vindicate to him the character of possessing greater abilities, and of being a better scholar, than any boy then in the school. Early in 1797 he was elected to a studentship at Christ Church, Oxford; and he maintained in that University a reputation as distinguished as that of his earlier years. Besides College prizes which he obtained, taking always the first place, he gained, we believe in 1799, the University Under-graduate's prize, for a Latin poem, the subject of which was "Religio Brahmæ;" and which was characterized, as his verses always were, by a fine poetic taste, and a peculiar facility of expression, and harmony of numbers.

When the Rev. Dr. Carey, now Lord Bishop of Exeter, went from Christ Church, as Head Master of Westminster School, in 1803, Mr. Conybeare undertook, temporarily, the office of an usher at that seminary: this, however, was much below his talents, and he returned, in a short time, to Christ Church; but not until his usual kindness had made him generally beloved by the boys of the form over which he was placed. About this time he had a Laboratory, "and busied himself much with chemical experiments;" thus, perhaps, laying the foundation for that interest in scientific subjects, which subsequently led him, as a relaxation, by change of intellectual employment, to those few researches in geology, chemistry, and the history of science, the results of which, for the most part, are recorded in the *Annals*: and the character of these is such, that did we not know him to have been otherwise employed in promoting objects of equal utility, we might have wished that his scientific researches had been greatly extended. But we shall return to this subject in the sequel.

In 1804 or 1805, that great scholar and distinguished prelate the late Archbishop Markham, having accepted the resignation by Dr. W. Conybeare, of a stall which he held in York Cathedral, presented his son to it. About the year 1807, Mr. C. was chosen Professor of Anglo-Saxon in the University of Oxford; and in 1808 or 1809, he held the perpetual Curacy of Cowley, near Oxford, as an appendage to his Studentship.

About this time he communicated various articles to the British Bibliographer, under the signature of C.; and amongst others, we believe, an Abstract of all that had been published on Saxon Literature: he had previously made some communications to the Censura Literaria; among them a short memoir of W. Stevens, Esq. FSA. and Treasurer of Queen Anne's Bounty, celebrated for his learning in Divinity, and the intimate friend from youth of Bishop Horne. In 1809, he printed, for private distribution only, an abstract, in George Ellis's manner, of the celebrated French metrical Romance of Octavian, Emperor of Rome; the only exemplars of which are the manuscript in the Bodleian Library from which Mr. Conybeare made his abstract, and an indifferent translation into English, in the Cottonian Library. In November, 1811, he communicated to the Society of Antiquaries an inedited fragment of Anglo-Saxon poetry, contained in a MS. Volume of Homilies in the Bodleian Library; and presenting a specimen of our language and poetry, at the latest period at which they could fairly be denominated Saxon; Wanley supposing it to have been written about the time of Henry the Second; and Mr. Conybeare himself, from its inferiority to earlier specimens, placing the time of its composition lower than the era of the Norman Conquest. This communication is printed in vol. xvii. of the Archæologia.

In the year 1812, Mr. Conybeare was elected to the office of Regius Professor of Poetry in the University of Oxford; and was presented by his College to the Vicarage of Bath Easton, near Bath, which he held until his death. Whilst Professor of Poetry he made some valuable communications to the Society of Antiquaries; of which learned body, however, he was not a Fellow; a circumstance somewhat remarkable, considering, that next to Theology, his active attention was principally engaged by Antiquarian Literature. The communications to which we allude were as follows:

The seventeenth volume of the Archæologia contains, besides the fragment of poetry just alluded to, three papers by Mr. C. presenting extracts from as many poems contained in the volume of Miscellaneous Saxon Poetry given by Leofric, the first bishop of Exeter, to the Cathedral Church of that diocese, and still preserved in its capitular library. These extracts he accompanied with literal translations into Latin prose, preserving with the most scrupulous fidelity both the sense and verbal construction of the original; and with paraphrases somewhat more liberal in English verse. "I have always considered this double version," he observes, "as the readiest means of enabling those who are unacquainted with the language of the originals, to form at the same time a tolerably

correct notion of their characteristic structure of sentence, and a fair estimate of their merits as poetical compositions." And though he proceeds to regret his inability to execute the English versions in a manner more worthy the spirit of his author; yet those who read them will find that he has accomplished the task with much success: the character of his versions is at once simple and dignified, and adapted with much taste to the varying style of the original poems.

The same volume contains two papers, communicated to the Society in 1813, on the metre of the Anglo-Saxon poetry; containing observations, suggested, in the first instance, by the perusal of two very interesting documents contained in the Exeter Manuscript; and showing the origin and the fallacy of the contradictory opinions which our ablest philological antiquaries had advanced on the subject. He proves, in the first communication, that the poetical compositions of the Anglo-Saxons were distinguished from their prose by the continual use of a certain definite rhythm; and investigates, to a considerable extent, the metrical structure of those venerable and interesting remains. In the second paper he adds such further remarks on their peculiar characteristics as had been suggested to him by an attentive examination of the principal works of this description, preserved either in print or in manuscript.

In the following year our indefatigable Professor communicated to this Society, two short poems of the time of Richard II.; which occur in the latter part of an immense manuscript volume of English Poetry preserved in the Bodleian Library, and usually styled, from the name of its donor, the Vernon Manuscript. They present a lively picture of the popular feeling, towards the commencement of the weak and disastrous government of that monarch.

In November 1814, he transmitted to the Antiquarian Society, for exhibition to its members, a copy of an early English work, entitled, "A Hundred Merry Tales;" and printed by Rastell, but without a date, in small folio; 22 leaves, pp. 44. He had found this work converted into pasteboard, and forming the covers of an old book: as it had previously been known only from the casual mention of its title by Shakespeare, its discovery excited much interest among the students of the literature which the history and explanation of his works has created. We subjoin the following extract from Mr. Conybeare's communication respecting it:

"The name of Shakespeare has given such value to every thing, however trifling, which can tend to the explanation or illustration of his works, that I perhaps scarcely need apologize for submitting to the inspection of the Society of Antiquaries, a copy, which, though much mutilated, is, I believe, unique, of

an early English work hitherto known only by his casual mention of its title 'The Hundred Merry Tales.'

"From this jest book Beatrice is accused by Benedick of purloining an article in which it certainly would not in our more refined times be thought to abound—her '*good wit.*' No copy of the work in question having hitherto been discovered by collectors, it has been conjectured alternately, that the expression of Beatrice* refers to some early translation of the Decamerone, the Cento Novelle Antiche, or the Cent Nouvelles Nouvelles. There can now, however, I think, remain little doubt but the small volume transmitted herewith (which both corresponds in title with the supposed magazine of Beatrice's wit, and is in fact a mere collection of short ludicrous anecdotes and repartees) is the very work alluded to by Shakespeare.

"The Tales as far as I have examined them are mostly of English origin: a few of them have descended, with some little modifications, to those cheap '*Merriments*' which most of us can probably recollect to have afforded amusement to our childish years.

"It is not impossible that a more accurate examination might discover in the work, some further illustrations of our early literature and manners than that afforded by the title. At all events it is remarkable as being probably the first book of jests printed in our language."†

In 1815 The Hundred Merry Tales were reprinted for a select literary circle, and dedicated to Mr. Conybeare, by S. W. Singer, Esq.; a gentleman well known for his attachment to our older literature.

Mr. Conybeare's last communication to the Society of Antiquaries was made so late as the month of November 1823, and was contained, like all his previous communications, in a letter to his friend Mr. Ellis. This was an abstract of a contemporary poem on the Siege of Rouen, by Henry V. in 1418, composed by an eye-witness; and lately discovered in the Bodleian Library. A transcript of this poem by Mr. C. of which the abstract was merely a precursor, is expected to appear in the next volume of the Archæologia.

The ancient literature of this country, however, formed but a small portion of his attainments: as a classical scholar, not perhaps as a *scholiast*, but as an elegant cultivated scholar, he eminently excelled; and in Theology, on which he had of late years fully and properly concentrated his talents, he has not perhaps left behind him his equal for extensive acquaintance

* 'That I was disdainful,—and that I had my good wit out of *The Hundred Merry Tales*;—Well, this was Signor Benedick that said so.'—*Much Ado about Nothing. Act.* 2, *Sc.* 1.

† Archæologia, vol. xviii. p. 430.

with the whole field of inquiry: his deep and varied information on every part of it was unrivalled, and stood widely distinguished from the narrow erudition which sometimes passes current. This renders it a subject for regret that the Sermons he recently preached at the Bampton Lecture, printed only for limited circulation, and a Reply to Palæoromaica, should form his only publications of a theological nature.

Though Mr. Conybeare never appeared to labour, "yet his mind was too active not to demand almost constant occupation; and he therefore naturally sought for relaxation in change of intellectual employment: thus he occasionally pursued, and with much keenness, a great variety of subordinate objects; such as the history of art,—the history of languages,—the literature of the middle ages,—mineralogy, and chemistry; but though in all these powers like his could not fail to give him a respectable rank, yet, to them, those powers never were applied, or intended to be applied, with sufficient earnestness to ensure any very distinguished progress;" except in those departments of antiquarian literature to which we have already adverted.

The Transactions of the Geological Society, and the new series of the *Annals*, contain, we believe, all Mr. Conybeare's papers on scientific subjects. In the second volume of the former work he published some "Memoranda relative to Clevelly, North Devon;" in which, having visited the spot in company with Mr. Buckland, he describes the singular contortions in the grauwacke forming the cliffs near that town; illustrating his description by sketches: and recommending the establishment of a line of separation, in the subdivision of our rocks, between the rock which under the names of dunstone and shillat covers so large a portion of the North of Devon, and that metalliferous slate which lying immediately upon the granite of Dartmoor and Cornwall, forms the most considerable part of the mining tract in both counties. In the fourth volume of the same work are some "Memoranda relative to the Porphyritic Veins, &c. of St. Agnes, in Cornwall;" drawn up by Mr. C. principally from the notes of Mr. Buckland, with whom he examined them. The authors were in almost every instance strongly tempted to regard the elvans, as the rocks forming those veins are provincially termed, as of contemporaneous formation with the schistose rock which they traverse. In the same volume is a "Notice of Fossil Shells in the Slate of Tintagel," by Mr. Conybeare; and the following additional papers by him have been read before the Society, and will appear, we presume, in the forthcoming part of its Transactions:—"On a Substance contained in the Interior of certain Chalk Flints:" "On the Comparative Fusibility of certain Rocks, and the Character of the Results;" the experiments described in this communication, were undertaken chiefly with

a view of comparing the characters of the indurated lias shale (found in contact with the whin dykes) of the north of Ireland, with those of certain rocks to which it had been supposed to bear an analogy. The results tended, in Mr. Conybeare's opinion, to establish the identity of the Irish rock with the shale of the lias formation, as occurring elsewhere, rather than with the true flinty slate, or any other variety of basalt: and lastly, two notices "On a recent Ligneous Petrifaction."

It will be sufficient to enumerate merely his papers in the *Annals:* they occur in the following order, in the present series. In vol. i. he described an inflammable substance found filling small contemporaneous veins in the ironstone of Merthyr Tydvil; and to which, believing it to be undescribed, he gave the name of Hatchetine, in reference to the eminent chemist to whom we are indebted for so many valuable contributions towards the history of the bituminous substances. In vol. v. he communicated a further examination of this body; but finding, subsequently, that it had first been mentioned by Mr. Brande, in his Manual of Chemistry, under the appellation of mineral adipocire, he withdrew the name of Hatchetine, and acknowledged Mr. Brande's priority of observation. In the first volume, likewise, is a short paper by Mr. Conybeare, "On the Red Rock Marle, or Newer Red Sandstone;" as it is presented in the strata extending from Dawlish to Teignmouth: this contains a more precise examination of the rolled masses of various rocks included in the breccia of this formation than any account hitherto published; for which reason, the authors of the "Outlines of the Geology of England and Wales," have given it nearly entire in that excellent work.

In vol. ii. is an article by our author, "On the Geology of the Neighbourhood of Okehampton, Devon." In vol. iv. papers "On Siliceous Petrifactions imbedded in Calcareous Rock;" "On the Geology of the Malvern Hills;" "On Works in Niello and the Pirotechnia of Venoccio Biringuccio Siennese;" and "On the Greek Fire." In vol. v. "Queries on the Plumbago formed in Coal Gas Retorts;" "Examination of Mumia;" and "On the Geology of Devon and Cornwall." In vol. vi. a continuation of the last-mentioned article, and an account of a scarce and curious alchemical work, the "Symbola Aureæ Mensæ Duodecim Nationum," of Michael Maier.

The admiration excited by the talents which could be directed, and so successfully, to such varied objects, has thus far rendered the task of recording the life of their possessor a pleasing one; but we now come to a painful part of the subject. Early in the month of June last, Mr. Conybeare came to the metropolis; partly on business connected with the printing of his "Illustrations of the Early History of English and French

Poetry ;" which had been announced for several years, and the Anglo-Saxon portion of which was considerably advanced. He was seized with apoplexy on the 10th of June, and died on the following day; at the house of Stephen Groombridge, Esq. FRS. at Blackheath. On the 20th, his remains were interred in a spot chosen by himself, in the church-yard at Bath Easton ; his brother, the Rev. W. D. Conybeare, and brother-in-law, the Rev. Charles Davies, being chief-mourners ; and his parishioners, with the clergy and gentry of the vicinity, attending the ceremony.

We cannot better terminate this article than with an extract from the tribute paid to Mr. Conybeare's memory by his warmly attached friend Archdeacon Moysey.

" His talents were of the very first-rate description. In languages, in poetry, in taste, he was distinguished far above his contemporaries : in chemistry and mineralogy he possessed a more than common degree of information. The writer of this slight sketch speaks from intimate personal knowledge of very many years, when he says, without fear of contradiction, that whether as boy or as man, he never met his equal. His goodness of heart was unbounded. No calamity of others came unheeded under his eye ; nor was any thing which kindness could do for another ever omitted by him. Nor can we wonder at this, when we turn to the most valuable point, in a character valuable on all points ; namely, his deep and unfeigned piety. There was in him a spirit of true devotion, a singleness of heart, a purity of ideas, which rarely, very rarely, have been found. Never did he lose sight of the responsibility which he had taken upon himself in the character of a parish priest. The multitudes who attended his interment, both of rich and poor, bore just testimony to the character of him who had been truly the father of his parish ; the friend of the poor ; the comforter of the afflicted. In his Saviour's path he trod with diligence on earth, and well may we trust that he has now departed to that fulness of joy which is prepared in that Almighty Saviour's presence for them who follow his steps." E. W. B.

ARTICLE II.

The Bakerian Lecture.—On certain Motions produced in Fluid Conductors when transmitting the Electric Current. By J. F. W. Herschel, Esq. FRS.*

1. HAVING had occasion, in the course of some enquiries respecting the decomposing agency of the Voltaic pile, to electrify mercury in contact with various saline solutions, I was surprised to observe motions take place in the fluid metal of a violent and apparently capricious kind, for which, as I had uniformly operated with very feeble electric powers, there seemed no adequate cause. Frequently it would be agitated with convulsive starts; sometimes currents and eddies of great violence would be formed in it; at others, it would spread and elongate itself, ramifying out into the most irregular forms; and altogether presenting appearances of a nature so singular, as induced me to make experiments with a view to ascertain their cause, or at least the circumstances essential to their reproduction.

2. The singular convulsive agitations into which mercury is thrown when placed within the circuit of a powerful Voltaic battery discharged through water, has been noticed by Sir H. Davy, in his Elements of Chemical Philosophy. Pure water, however, is so very imperfect a conductor, that great Voltaic powers must be used; and the phænomena are then too irregular, and the agitations too violent for distinctness. It is only when liquids which conduct well are used to form the circuit, that they become regular, and can be studied at leisure under the influence of moderate electric energies.

3. If a quantity of very pure and perfectly clean mercury, free from the slightest superficial film, be placed in a Wedgewood-ware evaporating basin (which must also be scrupulously clean), and covered to the depth of about a quarter of an inch with concentrated sulphuric acid, and the extremities of two wires of platina in connexion with the poles of a Voltaic† apparatus be immersed *in the acid only* on opposite sides of the mercury, but not in contact with it; immediately a rapid circulation will be seen to take place in the acid, owing to a violent current which establishes itself between the two wires, setting directly across the mercury in a direction from the negative (or zinc) towards the positive (or copper) pole. This current is kept up steadily, and without any change in its direction or

* From the Philosophical Transactions for 1824. Part I.

† The battery I employed in this and the subsequent experiments (unless where the contrary is expressed), consisted of ten pairs of single plates, each of fourteen square inches in surface, excited by mixed nitric and sulphuric acids much diluted.

force so long as the pile remains in activity, and only flags, and at length ceases, when its energy is quite exhausted. The mercury is not sensibly tarnished or otherwise acted on, and, after the experiment, is found to have undergone no change; nor is the acid sensibly altered, with the exception of the trifling portion decomposed, and a minute quantity of mercury taken up.

4. If we examine the phænomena more attentively, we shall observe that the particles of the acid in immediate contact *with the mercury,* are those which move most actively, being darted along its surface with surprising violence; those above them, and more remote, appearing rather to be dragged or forced along by them, than impelled by any force acting directly on themselves. We shall perceive too, that, if some distance intervene between the wires and the edges of the mercury, the current will be confined, and the circulation take place in the immediate neighbourhood of the mercury *only,* the liquid around the wires being nearly, or quite at rest.

5. If the centre of the globule or disc of mercury be situated in one straight line with the extremities of the wires, the current will set diametrically across it; but if this be not the case, it will follow a curvilinear course, every elementary filament of it having a different curvature, and each traversing the mercury in a path having a common origin and termination, viz. the points (*z*) and (*c*) of its surface nearest to the negative and positive poles respectively.

6. If the globule of mercury be of considerable size (four hundred or five hundred grains for instance), it will be observed to elongate itself in the direction of its axis towards the negative wire, and if near enough, will reach and amalgamate with it: but if it be small, its whole mass will move bodily with more or less rapidity, as if attracted to the negative wire. This apparent attraction is often very energetic, the globule moving with great velocity towards the negative wire, to which it immediately adheres. If the wires form a triangle with the situation of the globule while at rest, the latter advances neither directly to the negative, nor directly from the positive wire, but in a direction oblique to both, approaching the negative wire in a spiral, and describing frequently several revolutions with increasing velocity before it ultimately falls into and amalgamates with it, like a body acted on at once by an attractive force tending to the negative, and a repulsive, from the positive wire.

7. These apparent attractions and repulsions, this elongation of large masses of mercury and bodily motion of small ones toward the negative pole, are in reality, however, only secondary effects; their immediate cause, as well as that of the currents in the surrounding acid, will be discovered by a more minute attention to what takes place in the mercury itself, while under the influence of the electric action.

8. To this end, if we operate on a considerable mass of mercury, and, instead of covering it with the acid, merely moisten it and the containing vessel, making the circuit as before, only by the medium of the thin film of acid which adheres, the circulation of the mercury will be not less violent; but it will then be evident that the origin of the motion is in the mercury itself, the acid film being (so far as mechanical impulse is concerned) merely passive, and dragged along by its adherence to the mercury, coating it frequently with a stratum so thin as to reflect iridescent colours over its whole surface, and render the phænomenon extremely beautiful. The motion of the mercury consists in a continual radiation of its superficial molecules from the point nearest to the negative pole, by which it is kept in a constant state of circulation, each particle being urged along the surface from the negative to the positive pole and returning along the axis. Were the mercury insulated from contact with the bottom of the sustaining vessel, and devoid of adhesion to the liquid, the momentum of the portions going and returning would be equal, and the centre of gravity of the whole mass would remain at rest; but by reason of the friction and adhesion of the fluid metal to the vessel and liquid, these re-act on the globule in a direction contrary to that of the superficial currents, and the centre of gravity accordingly advances in that direction, or towards the negative pole. When this motion cannot take place, the internal current, having all one uniform direction, forces its way outwards to the negative pole, distorting and elongating the figure of the mercury in proportion to its energy. If the metal be oxidated, so as to give a certain tenacity to the superficial film, the radiating currents pursue their course under it; and the supernatant fluid, being thus defended from their action, remains at rest. In this case the only indication of their existence is the protuberance produced by the resultant interior streams.

9. A number of singular appearances are explained by this internal current. In some cases the mercury throws out projections or probosces of inordinate length, which take the direction of the electrified wire, and follow all its motions. The resultant interior current is in this case directed along the axis of the proboscis from its root to its extremity, which thus becomes an indication of a very powerful radiation along its surface in an opposite direction. In others, the mercury flattens throughout its whole extent, and, when this is the case, it is always covered with a thick coat of oxide. In these circumstances the superficial currents tend from the circumference towards the centre of the flattened mass, and the interior stream tends from the centre outwards in all directions, in a horizontal plane, thus continually urging the circumference farther and farther out, by diminishing the radius of curvature of the vertical section of its edge.

10. That friction against the vessel is the principal cause of the apparent attraction of a globule of mercury to the negative end, may be proved evidently by the substitution of a glass for a Wedgwood-ware basin. In this case the currents are produced as before; but, though equally forcible, the globule shows little or no tendency to move bodily, but if placed on a plate of emeried glass, or on any other rough surface, it will move with great activity; nay, so strong is its tendency to the negative pole, that globules of considerable magnitude may thus be sustained without contact of either wire, on surfaces many degrees inclined to the horizon.

11. It is essential to the production of the motions in question, that the mercury be in actual contact and free communication with the acid, and so situated as to be within the influence of the electric current. It is not necessary, however, that a continuity of the acid should subsist between the positive and negative wires; they will appear in any interrupted circuit of mercury and the liquid medium. The experiment indeed is difficult to try in sulphuric acid, whose capillary attraction for mercury is such that the least drop, applied to any part of a clean surface of that metal, instantly spreads over the whole, but with other conducting media it may readily be made. We have only to drop a little of the liquid to be tried on two different spots of a large clean surface of mercury, and bring the poles in contact with them, taking care not to plunge them in the metal, when the same phænomena will be observed to take place about each pole as if the whole surface had been covered with the liquid. The motions however are confined to such portions of the mercury as are actually covered, all the rest remaining quite still: the effects too are modified by capillary action.

12. When the circuit is completed in a conducting liquid, in the manner described in the beginning of this paper, the action is most forcible in the direct line joining the poles; its violence diminishing as we recede from this line, though it continues sensible to a great distance either way: and the course pursued by electricity in its passage through conducting media, and its law of distribution within it, may in some degree be traced, by placing globules of mercury in different parts of a liquid; when it will be plainly seen, that it is by no means confined, or nearly so, to the straight line between the poles, or to the surface of the conducting medium, but immediately on quitting the wires diffuses itself through the whole liquid, its density being a maximum in the space directly between them, and diminishing rapidly as we recede from their line of junction.

13. The mechanical action appears (*cæteris paribus*) to be proportional to the absolute quantity of electricity which passes, *dato tempore*, through a filament of the liquid at the point

where it is exerted. The magnetic effect is proportional (*cæteris paribus*) to the absolute quantity of electricity in motion present at once, (or at any indivisible instant of time) in a given portion of the conducting wire, or within the sphere of action of the needle, that is, to its density.* To establish or refute this distinction, will require experiments which it is easy to imagine, but which I have not yet had an opportunity of making. At first sight, indeed, the phænomena in question present a considerable analogy to the electro-magnetic vortices observed in the fluid metals; but on presenting very powerful magnets to the mercury, while under the circumstances above described, in various positions, I have never been able to perceive any influence exerted by them in accelerating, retarding, or deviating the currents; and moreover, these are incomparably more forcible in proportion to the electric powers used, than the motions produced by the action of magnets.

14. In consequence of this superior energy of action, the phænomena which form the subject of this Paper, furnish a test, perhaps, the most sensible yet known of the developement of feeble Voltaic powers. I constructed a small battery of zinc and copper wires twisted together, each pair being two inches long from the point of junction, and the wires $\frac{1}{30}$ of an inch thick. Ten pairs of these, excited by extremely dilute nitric acid, caused a rapid rotation in mercury, interposed under sulphuric acid between the poles, and a regular advance of globules of that metal towards the negative pole. The rotation continued with considerable force, when the wires were so far withdrawn as to have only their extremities in contact with the liquid in the cells, in which case the surface exposed by each pair to the action of the acid could not exceed $\frac{1}{50}$ of a square inch. Nay, so delicate is this indication, that the electricity developed by bringing the extremities of a thin zinc and copper wire in contact with a glass merely moistened with the above mentioned dilute acid, is abundantly sufficient to cause an immediate and unequivocal rotation in an ounce or two of mercury properly exposed to its action. By this means, indeed, the feeblest electrical excitement may be placed in evidence. I have

* In these expressions I have conceived electricity as being transmitted through conductors according to the laws of a gas of high, but variable elasticity through pipes more or less obstructed, a supposition which will represent many of the phænomena. The sluggish electricity of a single pair of plates may be compared to air, rendered dense and less elastic by excessive cold, while the active charge of a powerful battery, or the spark of an ordinary electrical machine, is in this view assimilated to air with all its energies exalted, and its density diminished by violent heat. The same quantity in weight may pass through the same conducting pipe in the same time; but in the one case the motion of each molecule will be comparatively much slower, and the actual quantity present at any instant of the discharge (*e. g.* an inch in length) of the conductor, much greater than in the other. I am well aware that this is merely an analogical representation of facts, and of course inaccurate, but it serves to explain the distinction in the text.

thus rendered *strikingly* sensible the electricity developed by a mere difference in the state of the surface of two small portions of copper wire from the same coil (one being a little cleaner than the other) not above an inch in length of either being immersed; or that set in motion by a copper and zinc wire held near together and dipped in common pump water, powers which it is not easy to render sensible by other means. For the success of these experiments, however, it is not enough merely to plunge the extremities of the conducting wires under sulphuric acid. The surfaces of contact *here* require to be greatly increased,* so as to insure the transmission of the whole of the electricity developed. The best way is to immerse them in two considerable pools of mercury under the acid, one on either side of the globule to be set in rotation.

15. Hitherto we have considered only the effect produced when a current of electricity is transmitted over mercury through sulphuric acid. When other conducting liquids and other metallic bodies are used, phænomena of the same kind are produced, but so modified by the nature of the substances employed, the intensity of the electric power, and the manner of conducting the experiments, as to become extremely perplexing; and I must warn the reader who may be inclined to repeat them, that he must expect to find them frequently fail, or even give contrary results from those I shall describe, owing to causes by no means easy to discover. The principal is impurity in the mercury used, and none should be used but what has been carefully distilled, and well washed with dilute nitric acid. It was long before I discovered this necessity; and ignorance of this essential condition engaged me in a series of tedious and disheartening repetitions of every experiment, till I was on the point of relinquishing the subject in despair, encountering contradictory results in operations conducted, as I then supposed, in a manner precisely similar.

16. When mercury, so purified and perfectly clean, is placed in any conducting liquid, and the circuit completed without bringing either pole in contact with the metal, the phænomena vary with the nature of the liquid; but, generally speaking, the effect is the production of currents more or less violent, radiating from the point nearest the negative pole. In the acids, particularly in the more powerful and concentrated ones, and such as are good conductors of electricity, they are decided and violent. In saline solutions their force is less, in proportion as

* The efficacy of an increase of surface for transmitting electricity *into* a liquid is remarkable. By bringing the positive pole in contact with a large surface of mercury, or still better, of an amalgam of mercury and zinc, over which a saline solution is poured, the reduction of the metals of the alkalies and earths at the other pole is operated with a degree of facility hardly to be imagined without trial. In this way the decomposition of ammonia may be effected with three pair of single plates of the above dimensions, in very moderate action.

the electro-positive energy of the base is greater. Thus, in the salts with a basis of potash they are feeble, and often only perceptible by a momentary start of the mercury when the circuit is completed. In those of soda, ammonia, baryta, strontia, and lime, they are more distinct, while in salts of magnesia, alumina, and the metallic oxides, their influence is still more sensible. On the other hand, under solutions of the pure alkalies and alkaline earths, the mercury remains quite quiescent, or at most is only agitated by feeble and irregular motions, depending on causes not now in contemplation.

(*To be concluded in our next.*)

ARTICLE III.

On the Applicability of Sir H. Davy's Discovery to Copper Vessels employed for Culinary Purposes. By Dr. Bostock, FRS.

(To the Editors of the *Annals of Philosophy.*)

GENTLEMEN, *Upper Bedford-place, Aug.* 2, 1824.

THE following experiments were undertaken in consequence of a conversation that took place on the subject of Sir H. Davy's interesting discovery of the mode of preserving copper from the action of sea water. The question was proposed, how far the same principle was applicable to the copper vessels that are employed for culinary purposes, whether it be necessary to have their interior surface completely lined with tin, or whether it might not be sufficient to have a portion of it only covered, which might protect the remaining part.

1. Three discs of copper were immersed in vinegar; the first, without any addition; the second, with one of its surfaces covered with a sheet of tin; the third, with a similar sheet of tin immersed in the fluid, but not in contact with the copper. After an interval of five weeks, the fluid belonging to the first disc was of a glaucous colour, and was found, by the action of ammonia and of potash, to contain a considerable quantity of copper dissolved in it. The vinegar in the two other vessels was opaque, and contained a considerable quantity of a light-brown sediment, which appeared to be an impure acetate of tin. The plates of tin were evidently much eroded, and the one which was not in contact with the copper had a coating of copper deposited upon its surface; no copper could be detected in either of the fluids.

The general fact being thus ascertained, the phenomena were examined with more accuracy. A colourless acetic acid was employed of such strength that 100 grains of it were neutralized by 66 grains of crystallized bicarbonate of potash; by the test

of muriate of barytes, it appeared to be free from sulphuric acid. Sheets of copper were used two inches in length by one in breadth, having, therefore, a surface of four square inches.

2. Three pieces of copper, weighing respectively 78, 77, and 74·5 grains, were each immersed in f ℥ jss of acetic acid, the first without any addition, the second with a sheet of tin of the same size with itself, and weighing nine grains, placed at about an inch from it in the fluid; the third, with a similar plate of tin closely applied to one of its surfaces.

3. In 37 days the acid in No. 1 had acquired a fine blue tinge, was clear and transparent; the copper was tarnished, exhibiting a blackish mottled appearance; it was found to have lost 1·5 grain.

4. The copper that was placed *opposite* to the tin was considerably tarnished and blackened, and was found to have lost 2·2 grs. The tin was evidently much eroded, and on the side opposite to the copper was covered with a black coating which was not easily detached from it; the fluid was opaque, and of a light-yellow colour, and contained a considerable quantity of a light-yellow precipitate. The tin was digested in ammonia; the ammonia gradually acquired a fine blue colour, and the tin was left perfectly clean, but with its surface exhibiting the appearance which has been termed *moirée;* it had lost 2·5 grains. The acid, after some days, deposited the yellowish substance, and became transparent; in this state it was not precipitated by potash.

5. The copper that was in contact with the tin was very slightly tarnished on the part exposed to the acid, and exhibited undulating lines of prismatic colours which were extended between the edges of the tin; its weight was not affected. The tin was evidently eroded; the surface in contact with the copper exhibited lines of prismatic colours, running in various directions; while the outer surface exhibited the *moirée* appearance; it had lost ·9 grain. The fluid exhibited the same properties with that in No. 4, but in a less degree.

6. For the purpose of comparison, a similar piece of tin was immersed without addition in acetic acid; it was eroded, exhibited on both sides the *moirée* appearance, and was found to have lost 1 grain; the fluid resembled that in No. 5. Hence it would appear that when copper is immersed in acetic acid with half its surface covered with tin, and the other half exposed, the copper is not dissolved by the acid. When the copper and tin are both immersed in the acid, but not in contact, the copper is dissolved in considerably greater quantity than when the tin is not present, but the whole of the dissolved copper is precipitated upon the surface of the tin. With respect to the action of acetic acid upon tin, when the same quantities of the materials are employed, the tin being either simply immersed in the acid,

being placed *opposite* to the copper, or being in contact with it, the quantities of tin dissolved were respectively as the numbers 10, 25, and 9.

7. I next wished to examine the effect of the vapour of acetic acid upon copper; for this purpose a sheet of polished copper was half immersed in acetic acid, so that an inch of it was above the level of the fluid. In six days the fluid was tinged blue; the part of the copper in the acid did not appear much affected, and there was a clean bright band of ·2 inch above the fluid; above this was a considerable crust of dark-blue crystals which covered the upper part of the plate, gradually becoming less dense, until towards the top it had the appearance of a thin sprinkling of a fine powder; the colour also gradually changing from a deep blue to a light bluish green.

8. A plate of copper weighing 76·8 grains was partially immersed in acetic acid, a sheet of tin weighing 6 grains being placed *opposite* to it, and completely immersed in the fluid. In seven days, the copper, with the adhering crust, had gained in weight ·2 grain; it was then immersed in water, so as to dissolve the crust, when it was found to have lost ·3 grain, making the whole weight of the crystals ·5 grain. The disposition of the crystals was as follows: the part of the copper that was immersed in the acid retained its polished appearance; at the surface of the fluid was a very fine black line, above this was a space of rather more than ·1 inch as bright and clean as the part immersed: above this there was a pretty well defined zone of dark-blue crystals, of nearly ·2 inch in breadth, while the remainder of the copper was covered with a greenish, powdery matter, more in quantity near the crystals, and gradually diminishing to the upper edge.

9. A similar experiment was performed, except that one of the surfaces of the copper was half covered with a sheet of tin, the upper edge of the tin coinciding with the level of the fluid; the copper weighed 74·5 grains, and the tin 10 grains. After immersion for seven days, the copper had ·6 grain of the crystalline matter adhering to it. The disposition of the crystals on the coated side of the copper was so far similar to that in the last experiment, that there was the clean space of about ·1 inch above the fluid, next the zone of dark-blue crystals, like those in No. 8, but more than twice their breadth, while above these crystals the upper part of the copper was nearly clean. On the uncoated surface of the copper there was a pretty distinct arch of crystals passing between the two upper corners of the tin, and rising about ·5 inch above the level of the fluid. The tin was considerably eroded, and exhibited much of the *moirée* appearance.

10. In order to compare the effect of acetic acid upon copper in the liquid state and in that of vapour, two similar plates of

copper were plunged into equal quantities of acetic acid, one of the plates projecting one-third above the fluid, while the other was wholly immersed in it. The blue crystals began to form on the upper part of the first piece of copper long before any effect could be perceived in the plate that was totally immersed. In 10 days the two plates were removed, the crystals were dissolved from the one that was partially immersed, when it appeared that the loss of weight in this was at least as considerable as in the plate that had been wholly immersed.

11. A plate of copper was half immersed in acetic acid saturated with potash; the upper part of the copper was scarcely affected; it was only slightly tarnished and a few minute crystals formed upon it at a little distance from the level of the fluid; the fluid remained clear and had acquired a bright blue tinge.

12. In order to observe how far the action of acetic acid upon tin, when copper is immersed in the same fluid, depends upon the extent of surface, two equal plates of copper were immersed in equal quantities of acetic acid; in one a sheet of tin was applied to the copper of three square inches in extent, in the other of one square inch only; in ten days they were examined, when the two sheets of tin were found to have lost very nearly the same weight.

13. In order to observe whether the contact of tin preserves copper from the action of oil or fat, two plates of copper were smeared with grease, the surface of one of them being half covered with a sheet of tin; nine days elapsed before any effect could be perceived in either of them, at the end of this time a faint shade of green was visible in some parts of the grease on the uncoated copper, and the colour has since continued to increase and to extend itself; no change has taken place on any part of the partially coated copper.

The practical conclusion that we may draw from the above experiments is sufficiently obvious; we find that copper is preserved by tin from the action of acetic acid in the same manner as it is from that of sea water; but that we cannot make use of this principle in vessels intended for culinary purposes, in consequence of the volatile nature of the acid. Most of the phenomena that were observed might have been anticipated from our previous knowledge with respect to the galvanic action of metals upon each other, and upon the saline solutions in which they are immersed. Such are the increased solubility of both the copper and the tin when placed in the same vessel of acetic acid, and the deposition of the dissolved copper on the surface of the tin; the greater quantity of the crystallized acetate of copper formed when the half immersed plate of copper had a sheet of tin plunged in the same fluid, and the small quantity of the acetate which was produced when the acid was rendered less volatile by being saturated with potash.

The description of the mode in which the crystals of the acetate of copper were disposed on the half immersed plates is a faithful representation of the appearances that presented themselves. The interval of bright copper between the apparent level of the fluid and the lower edge of the crystals is, I conceive, to be attributed to a thin film of the fluid which adhered to the metal, while the defined zone of crystals and the arched form which they assumed on the uncoated side of the plate, would appear to be referrable to some modification of galvanic action. To the same cause we must perhaps refer the bands of prismatic colours which passed across the copper between the two edges of the tin. But I am aware that these phenomena require farther examination. J. BOSTOCK.

ARTICLE IV.

On the best Method of chemically ascertaining the relative Values of the different Articles used for Tanning Leather.

(To the Editors of the *Annals of Philosophy*.)

GENTLEMEN, *Ross, Aug.* 17, 1824.

I SHOULD feel much obliged to you for the communication, through your *Annals*, of the best method that is known of chemically ascertaining the relative values of the different barks and other articles used for tanning leather, sufficiently accurate to guide the practical tanner. Elm and larch barks have been used of late years by some persons; but their value in regard to that of oak is very imperfectly understood. Vallonia, a Mediterranean product, a large kind of acorn, has been used to a considerable extent, especially for sole-leather; and more recently the bark of the cork-tree. By precipitating a solution of the tanning matter of cork-bark, and another of oak bark, by carbonate of potash, and then filtering and drying the precipitates, I find their value to be nearly as 15 to 8. Sumac, compared in tanning quality with oak bark, has been estimated as 5 to 2, but oak bark tannage is tougher. Two pounds of sumac will make one pound of leather. Five pounds of such bark as tanners in the country get are requisite for the same effect. Two pounds of raw pelt are necessary to make one pound of tanned leather. Dressing leather does not require so strong an ooze, or infusion of bark, as sole-leather. What would be the most economical method of extracting the tanning matter of these substances? I am, Gentlemen,

Your constant reader, F. C.

Article V.

Remarks on Light and Heat from Terrestrial Sources. By Baden Powell, MA. FRS.

Aug. 8, 1824.

(1.) In a former paper I made some remarks on the necessity of applying some certain and definite tests in order to discriminate different species of heating effects; and adverted to the application of such tests to the investigation of the nature of solar heat. Similar methods may easily be adopted in order to examine the constitution of the heating effect emitted or radiated from incandescent and burning bodies. This latter part of the inquiry is one of the greatest interest, and at the same time one which appears to require more particular examination than it has hitherto received.

The grand question regards the interception of radiant heat from the sources above-mentioned by a glass screen; and to this point have the well-known researches of Leslie, De la Roche, &c. been directed. Some questions which appeared to me to originate from those investigations, I have attempted to examine experimentally; and have had the honour of laying an account of them before the Royal Society, though at too late a period of the session (June, 1824) to admit of its being read before the vacation. It is not, therefore, my intention at present to enter upon any detail of those experiments, but merely to make a few incidental remarks on the design of them, and on the subject in general; and I only allude to the circumstances above-mentioned in order to account for any apparent delay in bringing forward the particulars of the experiments.

(2.) The object of these inquiries cannot be better elucidated than by taking a very brief review of the present state of opinions on the subject.

The celebrated experiments of Prof. Leslie on the interceptive power of screens (on Heat, Chap. 3), have most conclusively established that at temperatures not greater than that of boiling water the radiant heat emitted is totally intercepted by a plate of glass; and that any effect produced on a thermometer beyond it is owing solely to the heat which the screen has acquired and radiates again. His conclusions, however, do not immediately apply to the emission of heat at very high temperatures.

That there exist essential differences between the constitution of the heating power of *luminous* hot bodies, and that of the same power proceeding from those which are *non-luminous*, was

clearly pointed out by Prof. Leslie himself. (See his "Inquiry," p. 54, &c.)

The same distinction is also remarked by Biot as having been originally pointed out by Marriotte, the first observer of the reflection of heat by the same laws as those of light: "Qui a indiqué aussi la necessité de distinguer le *calorique obscur* et le *calorique lumineux*." (Biot. Traité de Phys. iv. 606.)

(3.) The subject having been taken up by M. De la Roche, results of the most important nature were obtained in several series of experiments, which, from their accuracy and elegance, have justly excited the admiration of the philosophical world. The account of them was communicated to the French Institute, and, according to the excellent plan adopted by that body, a report upon the examination of them was afterwards drawn up and published by the commissioners appointed for that purpose, MM. Berthollet, Chaptal, and Biot. A translation of their report may be seen in the *Annals of Philosophy*, O. S. ii. 161.

This distinguished philosopher extended the examination to a series of radiating bodies, extending from boiling mercury to incandescent metal, and flame in different stages of combustion. He tried the interceptive effects both of transparent and opaque screens on the radiant matter or influence proceeding from the substances in question, and acting on a thermometer, with its bulb blackened, and placed in the focus of a reflector, his results are given by Biot, Traité de Phys. iv. 640. The following extracts will best display the nature of the conclusions.

A greater effect was observed on the blackened thermometer beyond the glass screen in proportion as the temperature of the source of heat was elevated, and as it approached the state of luminosity, or became more perfectly luminous.

"Mais dans cet état même il y a encore des differences; car selon l'observation de Mariotte si l'on fait réfléchir la *lumière du soleil* au foyer d'un miroir concave de métal, et qu'ensuite on mette au-devant de ce miroir un *écran de verre*, il n'en résultera dans la température du foyer qu'une *faible diminution*, telle que $\frac{1}{7}$ ou $\frac{1}{8}$; mais si l'on fait la même expérience sur *le feu d'un foyer* ou *d'un fourneau* on trouvera que la réflexion directe sur le miroir *sans écran*, produira une chaleur très vive, et n'en produira qu'une *très faible*, ou insensible, si l'on interpose *la lame de verre* même en se rapprochant assez du feu pour que l'image lumineuse formée au foyer soit plus vive qu'auparavant."

Upon which M. Biot makes the following remark: "Or ce résultat que je ne fais qu'énoncer est de la plus haute importance; car d'abord l'inégalité de la transmission à diverses températures de la source rayonnante montre que les émanations calorifiques qui en partent dans les diverses circonstances sont *différement modifiées*: et en second lieu, la transmission plus abondante à mesure que le rayonnement calorifique *s'approche*

de l'état de lumière semble indiquer le progrès d'un *même* phénomène qui dans ses *modifications diverses*, agit sur nous inégalement, comme si les emanations *calorifiques* n'etaient que de la *lumière obscure*, et la *lumière* du *calorique lumineux*." (P. 612.)

(4.) Some observations bearing upon this subject occur in Dr. Brewster's elaborate paper on "New Properties of Heat, &c." in the Phil. Trans. 1816, Part I. His 40th proposition is directed to prove that radiant heat is not susceptible of refraction, and is incapable of permeating glass like the luminous rays. The truth of this is demonstratively shown from the curious properties examined in the previous parts of the paper, and shown to be communicated by heat to glass; and by the progress of which, the passage of the heat through the glass may be as clearly traced as if the heat itself were visible.

He applies this conclusion to the experiment of Sir W. Herschel, in which the concentration of simple heat by a lens appears to be proved. The thermometer must have received the heat radiated by the lens itself, and from the circumstance that the edges will cool first, the most copious radiation of heat will be in the direction of the axis. By a reference to Sir W. Herschel's paper (Phil. Trans. 1800, Part II. No. 15, Exp. 19, 20), it will obviously admit of question, whether in addition to the causes thus shown to be operating, the *light* from the red-hot metal may not have affected the thermometer. I have tried several experiments (an account of which will hereafter be given), from which it appears to me that the light from incandescent metal possesses a much greater heating power (using that term in the sense before defined) than might be anticipated from its small illuminating effect. Dr. Brewster's proposition, however, is a most important and conclusive one as to the incapacity of simple heat to undergo refraction, or to be transmitted in the way of direct radiation through glass. In connexion with the same point he also examines the conclusions of MM. De la Roche and Prevost. These observations I give in his own words:—

"The ingenious experiments of M. Prevost, of Geneva, and the more recent ones of M. De la Roche, have been considered as establishing the permeability of glass to radiant heat. M. Prevost employed moveable screens of glass, and renewed them continually, in order that the result he obtained might not be ascribed to the heating of the screen; but such is the rapidity with which heat is propagated through a thin plate of glass, that it is extremely difficult, if not impossible, to observe the state of the thermometer before it has been affected by the secondary radiation from the screen.

"The method employed by M. De la Roche of observing the difference of effect, when a blackened glass screen, and a transparent one, were made successively to intercept the radiant

heat, is liable to an obvious error. The radiant heat would find a quicker passage through the transparent screen, and, therefore, the difference of effect was not due to the transmitted heat, but to the heat radiating from the anterior surface. The truth contained in M. De la Roche's fifth proposition is almost a demonstration of the fallacy of all those that precede it. He found that "a thick plate of glass, though as much, or more permeable to light than a thin glass of worse quality, allowed a much smaller quantity of radiant heat to pass. If he had employed very thick plates of the purest flint glass, or thick masses of fluid that have the power of transmitting light copiously, he would have found that not a single particle of heat was capable of passing directly through transparent media." (P. 107.)

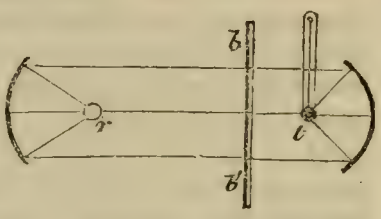
(5.) That a greater effect should be produced on the thermometer beyond the plain, than beyond the coated screen, appeared to me a curious circumstance. And when we consider how very little the thickness of the glass is increased by a coating of China ink, it would not seem likely that this alone could have been sufficient to produce the difference of effect observed. But there is still a further circumstance to be considered. The blackened side of the glass was towards the radiating body, and between it and the thermometer in the focus of the reflector. The coated screen must, therefore, have absorbed more heat, and we should in consequence be prepared to expect that it would radiate more to the reflector, and thus a greater effect be produced on the focal thermometer; which we know was not the case. This difference of effect was observed by De la Roche not only with luminous, but also with non-luminous hot matter.

The inference which seems to have been drawn is this:—Even when the hot body was non-luminous, the effect on the thermometer, with the *plain* glass interposed, was *greater* than with the blackened; but the transmission of heat by *absorption* and subsequent *radiation* must have been at least *equal* in the latter age to that in the former; and upon the established laws of absorption and radiation, it would have been *greater*. Hence it seems necessarily to follow that the effect through the plain glass must have been, at least in part, a *direct transmission* of the radiant matter, or influence, unaltered in its nature, and merely subjected to a certain loss of intensity.

(6.) Before we fully assent to the conclusiveness of this reasoning, there is one point necessary to be considered, which appears likely to affect the inference, and to afford a satisfactory explanation of the apparent difficulty.

The glass screen would necessarily be more heated at its central part than towards its edges; and neither would its whole area be exposed to the rays coming from the first mirror, nor the whole of the opposite surface be employed in radiating its

acquired heat so as to fall upon the second reflector; as will be evident by inspecting the subjoined diagram, which represents the arrangement of De la Roche's apparatus according to the verbal description.



It is here evident that the portions of the screen which fall without the area of the rays will not radiate their heat so as to produce much effect on the focal bulb *t*, and the parts *b b* of the blackened side will give out their heat more rapidly, and consequently abstract more from the other parts on the side away from the thermometer than when the glass was plain. And the same will be the case to a less extent even within the area of the rays, since the central point of the screen will be the most heated from the additional direct action of the hot body *t*.

With the plain glass there was neither so great an excess of heat (from its less absorptive texture), nor such a tendency to radiate it on one side rather than the other.

(7.) If the explanation here attempted be considered satisfactory, it will then be obvious that we are not obliged to infer from De la Roche's experiments that any *simple radiant heat* was transmitted directly through the glass. But in the subsequent cases, where the radiating body was raised to luminosity, it is evident that there was a much greater effect produced with the glass screen than can be reasonably accounted for by any secondary radiation; and the magnitude of this, compared with the total direct effect, obviously bears a close relation to the degree of luminosity.

(8.) In former, as well as recent times, several experimenters have noticed the fact that the effect of *luminous* bodies on a blackened thermometer is concentrated with the light in the focus of a lens, and that the glass itself does not become heated. See Mr. Brande's paper on Combustion, &c. Phil. Trans. 1820, Part I. sect. 2.)

Here then is a decisive proof that in these cases it is not a mere secondary radiation of the heat acquired by the glass, but an *actual transmission*.

(9.) From the labours of the different and distinguished experimenters who have examined this subject, we may, with certainty, learn thus much, that independently of the heat acquired and radiated again by the glass screen, there is, in the case of *luminous* bodies, a certain portion of the total heating effect *actually transmitted*.

(10.) What then, we have now to inquire, is the *nature* of this transmissible effect? Is it merely simple radiant heat to which the great elevation of temperature communicates properties which at lower temperatures it does not possess? If so,

why is any part of the total effect intercepted? And that this is the case, may be readily seen in the latter cases of De la Roche's experiments, as well as in many others.

If it be merely *light* into which, on Prof. Leslie's hypothesis, the radiant heat of the body has been gradually converted, the *whole* effect ought to be transmitted; since the diminution which *light* suffers in passing through a plate of clear glass would be very trifling.

(11.) All these and any similar questions which might arise, appear to me capable of solution by merely extending the inquiry as to the connexion subsisting between the *interceptive power of glass* in different instances, and the relation which both the intercepted and the transmitted portions of the effect bear to the *nature of the surfaces* on which they act. By obvious experimental methods, we might examine whether the transmitted part affects differently coloured, and differently textured, surfaces in the same proportions as the total or direct effect does. And each may be compared with what we know of the properties in reference to these points, by which both simple radiant heat, and the heating power of the solar light, are characterized. Thus we may clearly ascertain by the application of definitive tests, whether the portion intercepted be similar to simple heat in its relation to the texture of the surfaces on which it acts most powerfully; if so, it agrees with the "radiant heat" from non-luminous sources in the two characteristics by which it may be defined. If again, the transmitted portion agree with the solar light in acting more energetically on surfaces of a darker colour, this would prove its joint possession of these two properties whose combination marks the "heating power of light." Such an examination would thus decide whether the radiating influence be due to one simple agent or to the joint, though distinct, operation of two.

(12.) In describing my observations on the solar rays, I alluded to the extension of the same examination to other cases. This constitutes one principal part of the experiments referred to in the present instance.

Two thermometers coated, one with chalk and the other with Indian ink, were exposed precisely in the same way as before, both with and without a screen of plate glass to the radiation from non-luminous hot iron; from the same iron at a bright red heat, and from the flame of an Argand lamp. Instead of the same ratio in the effects on the white and on the black bulb being preserved, as in the case of solar heat, I found a very considerable difference. When the rise of the two thermometers was observed *with the screen*, the ratio subsisting between them was very considerably *greater* than that which was obtained without the screen. The same thing was also tried in other ways by several applications of the differential thermo-

meter having its bulbs variously coated. I must, however, for the present refrain from going into further particulars, except to make an observation on the mode of experimenting with two thermometers and a glass screen.

(13.) It may possibly be said that the screen might exert a cooling influence, which would, from the nature of the coating, produce a greater fall in the white than in the black thermometer; and thus a difference in the ratio of the two effects might result. Any such effect would, however, be fully counteracted by the sizes of the bulbs employed. The effects of the coatings, supposing them laid on nearly as in the former experiments, (See *Annals*, Aug. § 38.) would be, white : black :: 100 : 89, and the diameters of the bulbs were respectively 0·6 and 0·55 inch. Hence we have the ratio very nearly, white : black :: 100 : 90, from which it is obvious that any cooling effect would be completely counterbalanced.

But independently of any such considerations in most of these experiments, more was to be apprehended from the heating, than from the cooling power of the screen. And though in experiments with the differential thermometer, where the bulbs were nearly equal, the latter effect may have sensibly interfered, yet the former probably much more than counterbalanced it; and in allowing for it regard was had to this consideration.

(14.) In speaking of the radiation from red hot iron (above § 4.) I alluded to the heating effect of the light which it emits. Relative to this point so intimately connected with the subject here proposed, I may be permitted to make a further remark. On this point M. Biot has brought forward some observations which require attention. When describing De la Roche's experiments, and speaking of those in which he employed hot metal, he observes in a note:

" On pourrait au premier abord, être étonné que De la Roche ait appuyé en partie sa proposition sur des expériences faites avec un lingot de cuivre amené a la température de 960° ; car à cette température il devait être en incandescence ; mais il s'est assuré que la portion de lumière qui s'en dégageait alors ne pouvait, comme lumière échauffante, influer sur l'ascension du thermomètre que dans une proportion infiniment faible. Car, en comparant les distances auxquelles les mêmes caractères d'impression pouvaient être lus à l'aide de cette lumière, et avec celle d'une simple bougie, il a trouvé qu'on ne pouvait certainement pas lui attribuer $\frac{1}{240}$ de l'effet total."—(Traité de Phys. iv. note, p. 642.)

As I have already remarked, it seems scarcely allowable to infer that the heating must accord with the illuminating power of light from *different sources;* indeed, in this respect, it has long appeared to me more than probable that differences to a

very considerable amount may exist between the calorific properties of light produced from sources of a different description, in comparison with their illuminating intensities. In this point of view, therefore, I cannot feel the force of the above reasoning; but further, by means of Leslie's Photometer, we can easily and decisively ascertain what is the amount of the heating power belonging to the light of incandescent metal, as distinct from all other heating influences which might be supposed to accompany it. This is an experiment which, as before remarked, I have repeatedly tried with iron raised to the highest point of brightness which a common fire could communicate. After observing and allowing for the effect of adventitious light, I was somewhat surprised at the magnitude of the effect displayed by the very weakly illuminating rays proceeding from the hot iron. In 30 seconds the rise observed, in several different repetitions, was from 10 to 13 degrees. The bulb was coated with Indian ink, and enclosed in the glass case.

To guard against the possibility of any simple heat affecting the bulb, which, in the short time of observation, might not be counterbalanced by radiation; the precaution of interposing a screen of plate glass about half way between the instrument and the iron was adopted. The whole distance was nearly eight inches. The iron, a cylindrical mass about six inches long and 1·5 diameter, suspended vertically, the bulb of the photometer opposite its middle point. At subsequent stages of the cooling process, till the mass of iron became quite dull, proportional effects were displayed by presenting the instrument to its light at successive intervals during a space of five minutes or more. These results form part of a set of experiments hereafter to be detailed, in which more numerous instances of this and other kindred phenomena will appear.

ARTICLE VI.

On the Combinations of Acetic Acid with Peroxide of Copper. By Jac. Berzelius.*

A KNOWLEDGE of the nature of salts containing an excess of base, and of the ratios in which different quantities of the same base combine with a determinate quantity of an acid, is of the utmost importance for a complete and unexceptionable exposition of the laws of chemical proportions. In some earlier memoirs, I have attempted to develope the proportions by which the quantity of base augments in sub-salts, and I have attempted on the same occasions to demonstrate that, at least in all the

* From Kongl. Vet. Acad. Handl. 1823, St. II.

cases which had come under my observation, these salts are so constituted, that a correspondence exists between the multiples of the base, and the number of atoms of oxygen in the acid; and that the compounds of acids containing, for example, 3 atoms of oxygen, (that is, when the oxygen of the acid in the neutral salt is thrice that of the base) take place in totally different multiples from those of acids containing 2 or 4 atoms of oxygen. In the former, the ordinary multiples of the bases are $1\frac{1}{2}$, 3, and 6; in the latter, they are 2, and 4; so that the resulting compounds are always in conformity with the general rule, that the oxygen of one oxide (that is, either of the acid or base) is a multiple by a whole number of the oxygen of the other. Subsequent experiments have shown, however, that some acids which contain 5 atoms of oxygen, while their corresponding acidules (acids in *ous*) contain only 3, do not combine with bases in such proportions, that the oxygen of the acid shall always constitute a multiple by a whole number of the oxygen of the base; but that the oxygen of the base is 1, 2, 4, and 6 fifths of the oxygen of the acid, and 1, 2, and 4 thirds of the oxygen of the acidule. There are circumstances, indeed, which furnish grounds for a suspicion, that in this class of acid bodies, 2 atoms of the radicle combine with 3 atoms of oxygen to form the acidule, and with 5 to form the acid. And if, in that simple mechanical disposition of atoms which constitutes a compound atom, one atom of the radicle be supposed to occupy the same situation which would have been occupied by an atom of oxygen, had there existed in the acid an atom more of oxygen and an atom less of radicle, we shall be enabled to form an idea of the cause why the acidules combine with bases in the same multiples as if they contained 4 atoms of oxygen, and the acids as if they contained 6; in such a manner, that in sub-salts containing a maximum of base, the oxygen of the base is $1\frac{1}{4}$ ($1\frac{1}{3}$? time) that of the acidule, and $1\frac{1}{5}$ time that of the acid. We have instances of such compounds in the nitrite* and nitrate of lead, with the greatest excess of base. It is obvious that if in the salts produced by these acids, the oxygen of the base were (for example) one fourth or one sixth of the oxygen of the acid, they would constitute exceptions exactly analogous to those which would be formed by the other acids, where, in their salts, the oxygen of one constituent is not an equimultiple by a whole number of the oxygen of the other.

It may now be asked, do such compounds exist? The above-mentioned rules are purely empirical; that is, they merely announce that the compounds hitherto examined obey this law; but we are acquainted with no circumstances which render a

* Hyponitrite of Dr. Thomson.—*Tr.*

conformity to it absolutely necessary. Consequently, when any exception to the generally admitted rule appears to have been discovered, it deserves, before it be finally admitted as such, to be studied with the deepest attention, and to be confirmed by the most careful and intimate examination. A confir matory examination which I undertook of an exception of this nature, gave cause to the present memoir. Mr. R. Phillips * has examined the sub-acetates of copper which occur in commerce under the name of verdigris; and it follows from his experiments, that the oxygen of the acetic acid is $1\frac{1}{2}$ time that of the peroxide of copper, which is at variance with the above cited empirical law respecting the compounds of oxidated bodies. I have therefore studied the combinations of acetic acid with this base, and believe that the results which I have obtained are not altogether destitute of interest.

Before detailing my own experiments, I shall briefly relate what had been previously made known respecting these combinations. Chaptal endeavoured to investigate the difference between the verdigris manufactured in the neighbourhoods of Montpellier and of Grenoble, which are prepared by dissimilar methods, and are distinguished by dissimilar shades of colour. His examination was conducted by submitting them to dry distillation, and he found the one variety to contain a larger quantity of copper than the other; but his experiments left the proportions of the constituents of verdigris wholly undetermined.

Proust undertook a more complete investigation. He ascertained that in the salt saturated with acetic acid, the oxide of copper constitutes 39 per cent.; but he could not determine with certainty the relative quantities of the acid and of the water of crystallization. He at first regarded the verdigris which we find in commerce as a mixture of two distinct salts, one of which is soluble in water, while the other is not. The former he found to constitute 0·56, and the latter 0·44 of the weight of the verdigris. The insoluble salt, also, he found to consist of 0·63 of oxide, and 0·37 of acid and water. Some time after he altered his opinion respecting the constitution of verdigris, partly on the ground that it is decomposed by water; partly that, when diffused through water, a current of carbonic acid gas decomposes it into neutral acetate and carbonate of copper, and partly that when boiled with water it deposits black oxide of copper. The last mentioned property induced him to consider verdigris as a combination of neutral acetate of copper and hydrate of peroxide of copper, which is decomposed by boiling. He found in it 0·47 of neutral salt, 0·23 of oxide of copper, and 0·30 of water; quantities which agree very closely with the results of more recent analyses.

* *Annals of Philosophy*, N. S. vol. iv. p. 161.

Dr. Thomson calculated from Proust's experiments that the neutral acetate of copper is composed of 39·41 of oxide of copper, 25·12 of acetic acid, and 35·47 of water; and he adds, in his System, that he considers these to be the true constituents of the salt. More lately, Mr. Richard Phillips has resumed the accurate investigation of these compounds. He found the neutral salt composed of 39·2 oxide of copper, 49·2 acetic acid, and 11·6 water;* and its constitution, in his opinion, is 1 atom of oxide of copper, 2 atoms of acetic acid, and 3 atoms of water. In different experiments he obtained from 38·9 to to 39·5 per cent. of oxide of copper. To determine the quantity of acetic acid, he decomposed the salt by hydrate of lime. The uncombined lime remaining in the liquid was precipitated by carbonic acid gas; and after the excess of the latter had been expelled by ebullition, the solution of acetate of lime was decomposed by carbonate of potash, and the quantity of acetic acid was estimated from that of the carbonate of lime. He then examined verdigris, of which he had procured an uncommonly pure specimen; and an analysis, conducted in a similar manner, indicated as its constituents 43·25 oxide of copper, 28·3 acetic acid, and 28·45 water, which, in atoms, is equivalent to 1 atom acid, 1 atom oxide of copper, and 6 atoms water. When verdigris is decomposed by being treated with water, Mr. Phillips found that neutral acetate of copper (which he calls binacetate) passes into solution, and the green salt which remains undissolved is, according to him, composed of 2 atoms of oxide of copper and 1 atom of acid, or, when anhydrous, of 0·7619 of oxide of copper and 0·2381 of acetic acid. With respect to the black pulverulent substance into which this salt is converted by the action of water, he has left undecided, whether it consists of oxide of copper, or of a salt containing a still greater excess of base. In all of these analyses by Mr. Phillips, we are presented with deviations from the above-mentioned empirical rule; for, in the neutral salt, the oxygen of the water is 1½ time that of the oxide of copper, in verdigris the oxygen of the acid is 1½ time that of the oxide, and in the sub-salt obtained by treating verdigris with water, the oxygen of the base is to that of the acid in the proportion of 4 to 3.

1. *Neutral Acetate of Copper.*

I have already stated that Mr. Phillips considers the water of this salt to constitute 3 atoms for each atom of oxide of copper. This proceeds, however, from his having adopted an erroneous number for the atomic weight of acetic acid. By the direct analysis which I have made both of this acid and of its

* *Annals*, N. S. vol. i. p. 418.

combinations with different bases, I think I have determined with considerable certainty, that it contains 0·47 of its weight of oxygen, and that it forms neutral salts with a quantity of a base, whose oxygen is one third of that contained by the acid, that is $\frac{47}{3} = 15{\cdot}666$. Phillips found in the neutral acetate as much as 39·5 per cent. of oxide of copper, for whose saturation there would be required 51·17 of acetic acid; the deficit, which must be viewed as water, is 9·33, which corresponds, as nearly as can be expected, with the supposition that the oxygen of the oxide of copper and of the water of crystallization is the same, that is, that the salt contains only two atoms of water. Were the oxygen of the water 1½ time that of the oxide of copper, according to Phillips's calculation, the composition of the salt would be materially different, as will be rendered evident by the following comparison:

	With 2 atoms of water.	Multiples of oxy.	With 3 atoms of water.	Mult. of oxy.
Peroxide of copper	39·76	1	38·05	1
Acetic acid	51·22	3	49·00	3
Water	9·02	1	12·95	1½

The quantity of oxide of copper alone indicates decidedly to which of these two calculations our salt ought to be referred. In order, however, that I might not depend entirely upon preceding experiments, according to which the composition of this salt has been calculated in the tables (although there was no reason for doubting their accuracy), I made a new experiment with a view to determine with certainty the quantity of oxide of copper; and I employed for this purpose crystals of a salt which had never been dried otherwise then by long keeping: 100 parts of this salt were dissolved in dilute sulphuric acid; and after evaporation to dryness, the excess of sulphuric acid was expelled, by ignition over the flame of a spirit lamp. The sulphate of copper, which was in the state of small white crystalline grains, weighed 79 parts; and on being again exposed to a moderate red heat, it sustained no additional loss of weight. 79 parts of sulphate of copper are equivalent to 39·29 parts of oxide of copper; if we now abstract the water of decrepitation, which the crystals of this salt sometimes contain in considerable quantity, my result will be found to coincide still more closely with calculation. The formula and composition which I have given in my Chemical Tables for the acetas cupricus c. aqua, are therefore accurate.

2. *The Subacetates obtained by treating Verdigris with Water.*

Verdigris, when put into water, swells up, and is converted into a doughy mass, composed of minute crystalline scales. The filtered liquid, when in a state of concentration, has an

intense dark blue colour; but it is difficult to wash the insoluble portion thoroughly by this means, because the crystals speedily close up the pores of the filter. If verdigris be washed with water for a number of times in succession, the filtered liquid continues to retain its original intensity of colour; a proof, that it extracts to the last a compound which requires for solution a large quantity of water. This circumstance, together with the blue colour of the liquid, demonstrates sufficiently, that the solution does not contain merely the neutral salt, as has been stated by Phillips. When the blue liquid is heated almost to ebullition, it lets fall a flocky liver-brown coloured substance; after this it becomes green, and holds in solution the neutral salt. If, on the contrary, the blue liquid be evaporated in so moderate a heat, that it shall never appear brown, which is easily done, so long as it continues dilute, it deposits on the sides of the vessel, just at the edge of the solution, a confused blue coloured saline mass, of a peculiar dendritic appearance: the same salt accumulates on the edges of the filter, and shoots up into moss-like excrescences. By allowing this gradual evaporation to proceed to a state of dryness, the blue saline mass is also obtained, but mixed with crystals of the green neutral salt.

After the washing of the insoluble portion of the verdigris has been protracted for a considerable length of time, the liquid at last passes through colourless; and there remains upon the filter a blue coloured powder, which has usually a blackish tint, where it lies immediately in contact with the paper. Hence it follows that cold water converts verdigris into three distinct salts, namely, into the neutral acetate of copper, and into two sub-salts, one of which is soluble and the other insoluble in water. Verdigris when diffused through a small quantity of hot water does not become black. The solution has a dark blue colour, and contains a large quantity of the soluble sub-salt; on cooling, nearly the whole of this compound separates in the state of a blue coloured mass, which does not exhibit the slightest indications of crystallization. If the verdigris be boiled with a large quantity of water, it is rendered brown; and in proportion as the quantity of water employed for this purpose is augmented, the lower is the temperature necessary to produce this alteration, so that when the water is in great excess, it may be completely effected in a temperature so low as 104° (Fah.) In this experiment there is formed a brown sub-salt with a great excess of base, and the solution, provided it be very dilute, contains even a quantity of uncombined acetic acid, mixed with the neutral salt.

The Sub-salt soluble in Water.—This salt may be prepared in the following manner:—*a*. A solution of verdigris in distilled water is to be concentrated in a very gentle heat, until the

greater portion of its saline contents is deposited. The liquid, together with this deposit, is now to be heated, until the whole of the latter, which may consist of a mixture of the neutral and sub-acetates, is redissolved, and the concentrated solution thus obtained is to be mixed with alcohol. After about an hour, there is found deposited a bulky gelatinous looking mass, composed of an aggregation of minute crystals. These are to be collected upon a linen cloth, and thoroughly washed with alcohol. When dry, they have rather a pale blue colour.—*b*. A boiling-hot aqueous solution of the neutral acetate of copper is to be mixed with ammonia, so long as the precipitate thereby produced continues to be redissolved. The liquid is then to be filtered. On cooling, it deposits an irregular uncrystallized mass, and alcohol separates from the cold supernatant liquid a considerable quantity of the same compound, in the form of excessively minute crystalline scales. The salts thus obtained must be washed with alcohol, in order to free them from any adhering portions of the neutral salt; after this treatment, caustic potash disengages from them no traces of ammonia. If, during the preparation of this salt, the solutions are employed in a state of too great dilution, there separates, both by evaporation, and by the addition of alcohol to the solution of the neutral salt, a quantity of the insoluble sub-salt, which, when obtained in this manner, cannot be distinguished by its external appearance, from the soluble sub-salt precipitated by alcohol.

The salt, prepared by either of these processes, when exposed for some hours in the state of a fine powder to a temperature of 140°, lost in different experiments 9·5, 10, and 10·3 per cent. of its weight. The residue, which had acquired by this treatment a greenish tint, was boiled for an hour in water along with hydrate of barytes: the mixture was then filtered, and the oxide of copper washed. The filtered liquid was freed from its excess of barytes by a current of carbonic acid gas, after which it was evaporated to dryness with a moderate heat. The acetate of barytes, redissolved in water and filtered from the insoluble carbonate, gave with sulphuric acid 84 of sulphate of barytes, representing 36·8 of acetic acid. The oxide of copper was dissolved from the filter by an excess of muriatic acid. The solution, after filtration, was heated nearly to ebullition, and a slip of polished iron plate was introduced into it, with a view to precipitate the copper. The metallic copper, after having been thoroughly washed and dried, was transferred into a small apparatus prepared for this experiment, in which it was ignited, first in a current of atmospheric air, in order to burn away the charcoal deposited by the iron, and afterwards in a current of hydrogen gas, in order to reduce the oxide of copper. In this manner, I obtained 34·35 of metallic copper,

equivalent to 43·19 of oxide of copper. (In other experiments I obtained from 86·6 to 86·8 of sulphate of copper, which gives a similar result.) The oxide of copper and the acetic acid amount together to 79·99, and 10 of water had been expelled in the temperature of 140°; consequently 10·01 of water still remained in combination, that is, the salt lost one half of its water of crystallization, by the application of heat. 43·19 of oxide of copper contain 8·71 of oxygen, and 36·8 of acetic acid contain 17·3 of oxygen, that is, twice the quantity of the oxide of copper, for $8{\cdot}71 \times 2 = 17{\cdot}42$. The oxygen in the whole quantity of water amounts to 17·78, in one half of the water, therefore, it amounts to 8·89; a slight excess over the oxygen of the oxide, which is occasioned undoubtedly by the presence of some hygroscopic moisture. The salt, after having been exposed to a temperature of 140°, is constituted therefore of 3 atoms of oxide of copper, 4 atoms of acetic acid, and 6 atoms of water. The salt, before exposure to heat, contains 12 atoms of water, and is composed of

	By experiment.	By calculation.	Atoms.	Mult. of oxy.
Peroxide of copper ..	43·19	43·24	3	1
Acetic acid.	36·80	37·14	4	2
Water	20·01	19·62	12	2

The insoluble Sub-salt.—This compound may be prepared by allowing verdigris to swell up in water, and afterwards filtering it through coarse linen, which retains any impurities which may have existed in the verdigris, but allows the minute scaly crystals to pass freely between its threads. The crystalline scales are now to be separated by pouring the whole of the filtered portion upon fine cambric. They should be pressed closely together and washed a few times with water; after this, they should be transferred upon a paper filter, and thoroughly washed with alcohol. When obtained in this manner, they constitute a mass of small light blue shining crystalline scales, having a deeper and purer blue colour, than the preceding soluble sub-salt. Dried in a temp. of 212°, they lose only an inconsiderable quantity of hygroscopic water, and sustain no alteration in their appearance. When put into water, they swell up, as happens with verdigris, into a pasty mass.

Calcined in a balanced porcelain crucible, this salt left 64·25 per cent. of its weight of peroxide of copper. This calcination can be advantageously accomplished only when the sub-salt is in the state of hard lumps, and when the crucible is covered pretty closely with its lid until the whole of the acid be expelled: unless these precautions be attended to, the combustion of the mass is accompanied with slight detonations, and a portion of the oxide of copper is carried off mechanically by the disengaged gases. In another experiment, I obtained

129·4 parts of sulphate of copper by saturating 100 parts of the salt with sulphuric acid, expelling the excess of acid by evaporation, and exposing the dry mass to a low red heat. This corresponds with 64·36 peroxide of copper. A different quantity of the same salt, decomposed by hydrate of barytes in the manner described in the analysis of the sub-salt, yielded 63 per cent. of sulphate of barytes, equivalent to 27·6 per cent of acetic acid. For the water, therefore, there remains 8·04 per cent. The oxygen of the oxide of copper is 12·98, of the acetic acid 12·97, and of the water 7·15; consequently, the acid and base contain equal quantities of oxygen, and the water contains half as much as the oxide. The composition of this salt is therefore

	By experiment.	By calculation.	Atoms.	Mult. of oxy.
Peroxide of copper	64·36	64·82	3	2
Acetic acid	27·60	27·83	2	2
Water	8·04	7·35	3	1

If the salt contained 4 atoms of water, in which case it might be regarded as composed of 1 atom of neutral anhydrous acetate of copper, and 2 atoms of hydrate of peroxide of copper, the quantity of oxide would amount only to 63·27 per cent.; but in the analysis both of this specimen of the salt, and of others prepared on different occasions, I have invariably obtained more than 64 per cent. of peroxide of copper. At the commencement of my examination of this salt, I felt disposed to suspect that the differences of colour which it exhibits might be occasioned by a compound of this nature with hydrated peroxide of copper, which would probably possess a blue colour, and that, on the contrary, the green variety might be nothing else than an ordinary sub-salt. But experiment does not appear to corroborate this conjecture.

If a boiling hot solution of acetate of copper be mixed with caustic ammonia so long as the precipitate continues to be redissolved, and if after this treatment it be kept for some hours in a temperature of about 140°, there is deposited a blue crystalline salt, agreeing in composition with the preceding. If the liquid be now allowed to cool, it deposits the neutral acetate in crystals, and the soluble sub-salt in a cohering spongy uncrystallized mass.

If a solution of the neutral salt be precipitated by caustic ammonia, with the precaution that the whole of the acetic acid shall not be combined with the alkali, we obtain a green coloured gelatinous substance, which after having been washed becomes light blue coloured, but is never in the slightest degree crystallized. Towards the conclusion of the washing, alcohol must be employed in place of water, otherwise it will become black. This compound does not swell up when put into water, a property which seems to belong peculiarly to the crystalline

scales. On being examined, it was found to possess exactly the same composition with the salt last analyzed.

This sub-salt I have besides obtained by still different processes. For example, when hydrated peroxide of copper is macerated for some hours in a solution of the neutral acetate, it is converted into a light-grey coloured, heavy, pulverulent powder, which, when taken from the liquid and washed, becomes green. If a concentrated boiling hot solution of acetate of copper be mixed with caustic ammonia, with the precaution that no excess of the alkali be added, we obtain a heavy granular precipitate, of a dull greyish green colour, and which is uncommonly easily washed. Under a microscope this compound appears to consist of transparent, cubical crystals, having their corners rounded off. When heated, they decrepitate. All these dissimilar varieties, when treated with sulphuric acid, yielded 129·4 parts of sulphate of copper for every 100 parts of the dried salt: they all appeared therefore to constitute the same sub-acetate.

This combination, therefore, is the most easily formed, and possesses the best defined composition of all the sub-acetates of copper. The acetic acid is combined in it with thrice as much oxide as in the neutral salt. Since in this salt, the oxygen of the water of crystallization is only one half of what is contained by the peroxide of copper, I attempted, by digesting sub-sulphate of copper in a solution of acetate of soda, to produce an analogous compound, in which the oxygen of the water and of the oxide would be equal; but no mutual decomposition took place between the two salts.

In the three salts now analyzed we have found, therefore, that the oxide of copper combines with the acetic acid in the multiples in which bases usually combine with acids containing 3 atoms of oxygen, namely, 1, 1·5, 3. What is the constitution of verdigris?

3. *Verdigris.*

Verdigris occurs in commerce under very different appearances; sometimes it is green, sometimes it is bluish green, and very frequently it has a beautiful blue colour. Sometimes it dissolves in acetic acid, without leaving any residue of mechanically intermixed impurities, while, on other occasions, it leaves undissolved a considerable quantity of protoxide of copper. In general, however, we may refer it to one or other of two principal varieties, the green and the blue. These colours are most accurately distinguished, when the compounds are in the state of powder. What difference in the processes of manufacture occasion this dissimilarity in appearance, I have been unable to discover; because I procured the specimens for my experiments from merchants who were ignorant of the places

from which their stock of verdigris had been obtained. I satisfied myself, therefore, with selecting for this examination the greenest and the purest blue coloured specimens in my possession.

1. *The Green Variety.*—Dried in the state of powder, in the open air, this variety left after calcination from 44 to 44·6 per cent. of peroxide of copper. When previously dried in a temperature of 140°, it left from 49 to 50 per cent. 100 parts of a quantity dried in this manner, on being analyzed by hydrate of barytes according to the process already detailed, yielded 83·33 parts of sulphate of barytes, and 49·86 parts of peroxide of copper. This variety of verdigris, therefore, when dried in a temperature of 140°, was composed of

Peroxide of copper	49·86	containing oxygen	10·07
Acetic acid	36·66		17·23
Water, including loss	13·48		11·88

The quantity here stated as water, comprehends also certain foreign admixtures, which were in too minute a state of division to admit of being separated without loss. The result demonstrates pretty decisively, that the mass was a mechanical mixture, in which the sub-salt soluble in water formed a principal constituent. The property which the soluble sub-salt possesses of giving off half its quantity of water when dried in a temperature of 140°, is an additional proof that it constitutes a chief ingredient in this variety of verdigris, because the latter itself loses about 10 p. c. of water when exposed to a similar degree of heat.

2. *The Blue Variety.*—I obtained a remarkably pure specimen of this variety, which, when examined under a magnifying glass, was found to consist of an aggregation of very minute, shining, crystalline scales. Its powder had an uncommonly beautiful and pure pale blue colour, resembling that of the blue carbonate of copper when pulverized. Dried in a temperature of 68°, and analyzed by hydrate of barytes and by the precipitation of metallic copper, in the manner already described, 100 parts of it yielded

				Atoms.
Peroxide of copper..	43·34	containing oxygen	8·74	 1
Acetic acid	27·45		12·90	 1
Water.	29·21		27·97	 6

This result coincides with that of Phillips, and demonstrates that the oxygen of the acetic acid is 1½ times that of the base, and that the oxygen of the water is thrice that of the base. The blue species of verdigris, therefore, constitutes an indisputable exception to the empirical law. So long as we continue unacquainted with any other varieties of this compound, it will

be difficult to decide with perfect certainty, whether its constitution forms an actual exception to the law, or whether its component parts may not be considered to be in conformity with the law, but merely associated in more complicated combinations.

I shall here, without however professing to attach to it any particular importance, explain the view which I have endeavoured to take of the constitution of this compound. I dried 100 parts of the pulverized blue verdigris in a steam bath in the temperature of 212°, until it ceased to sustain any farther loss of weight. The residue weighed 76·55 parts. The powder had by this treatment diminished considerably in volume, and had acquired a fine green colour. These 76·55 parts are composed according to the preceding analysis of

Peroxide of copper	43·34	containing oxygen	8·74
Acetic acid.	27·45		12·90
Water	5·76		5·12

The oxygen of the water possesses no determinate relation to that of the oxide of copper: but if we suppose that the blue variety of verdigris is resolved, in consequence of the separation of water, into neutral acetate, and insoluble sub-acetate, (in which the acid saturates thrice as much base as in the neutral salt,) both retaining their usual quantity of water of crystallization, the mixture would consist of an atom of each, namely,

$$\ddot{C}u\ \bar{A}^2 + 2\ Aq$$
$$\ddot{C}u^3\ \bar{A}^2 + 3\ Aq.$$

That is, the oxide of copper existing in it would contain 8 atoms of oxygen, and the water 5. Now 8 : 5 :: 8·74 : 5·46. That the experimental determination of the water falls somewhat short of the theoretic, is occasioned probably by all the verdigris of commerce containing a slight admixture of the insoluble sub-acetate. The calculation is of course made on the supposition that the verdigris is in a state of complete purity. It is therefore pretty certain, that a temperature of 212° alone, without requiring the intervention of water, decomposes verdigris into an atom of neutral, and an atom of sub-acetate. We have also seen that water, both when cold and hot, is capable of accomplishing the same alteration. It cannot be doubted then, that in this compound the constituents are retained in union by very feeble affinities.

I at first conjectured, that, in the preparation of verdigris, the accession of oxygen is so limited, that an acetate of protoxide of copper only ($\dot{C}u\ \bar{A}$) is in the first instance formed, and that this compound, by absorbing oxygen from the atmosphere, is gradually converted into a salt of peroxide, through a

process similar to that by which epigenous crystals are produced in the mineral kingdom: it was easy to conceive that since the salt of protoxide retains its solid form during the whole period of its transformation, the constituents of the compound into which it is finally changed might be held together mechanically in very different proportions from those in which they would naturally combine, when enjoying a state of complete freedom. I had previously ascertained that when verdigris is distilled in close vessels with a very slowly augmented heat, there is obtained at a certain period of the process a white sublimate, which sometimes fills the cavity of the retort with a light aggregation of crystals, resembling wool. This sublimate is anhydrous acetate of protoxide of copper ($\dot{C}u\ \bar{A}$). I attempted, by exposing it to a moist atmosphere, to convert it into a compound containing the acid and base united in the same manner as in verdigris, but it underwent no alteration. When kept in water, it is decomposed, hydrate of protoxide of copper separating in the state of a yellow powder, and neutral acetate of peroxide of copper passing into solution, in proportion as the salt of protoxide absorbs a maximum of oxygen from the atmosphere. I stratified thin plates of polished copper with pulverized neutral acetate of peroxide of copper made into a paste with water, and exposed the whole for two months to an atmosphere which was constantly changing, but taking care, during the whole of that period, to preserve the mass in a state of saturation with moisture. At the conclusion of the experiment, the metallic plates were found covered with an incrustation of small, silky, shining, blue-coloured crystals of the blue variety of verdigris; and these, being separated and dried in the open air, yielded precisely the same analytical results as the verdigris which occurs in commerce. This result totally refutes the idea of an epigenous formation of verdigris, and demonstrates that copper, with the assistance of acid and water, acquires the property of combining with the previously formed neutral salt.

It appears to me not unlikely that the opinion of Proust, who regarded verdigris as a compound of the neutral salt with hydrated peroxide of copper and water of crystallization, may, perhaps, prove the most accurate. I have already endeavoured to show that the blue carbonate of copper (azure copper ore) is composed of an atom of hydrate of peroxide of copper, and two atoms of neutral carbonate of copper; and also that the artificial carbonate of zinc and magnesia alba are both analogous compounds of hydrate and carbonate.* More recently, an English philosopher † has discovered a blue crystallized mineral

* Afh. i Fysik, &c. vi. 12, et seq.

† Brooke, *Annals of Philosophy*, Aug. 1822, p. 118.

composed of an atom of sulphate of lead and an atom of hydrated peroxide of copper ($\ddot{C}\,Aq^2 + \ddot{\ddot{P}}b\,\ddot{\ddot{S}}^2$). Is it not equally possible that hydrated peroxide of copper may combine, under favourable circumstances, with acetate of copper? It may be objected that the quantity of water is greater than is required to form a hydrate; but such also is the constitution of the combinations of oxide of zinc and of magnesia already alluded to, and it is surely not assuming too much to admit an excess of water which is only double the water of crystallization contained by the two compounds when separate. On this supposition, the formula for the constitution of verdigris would be $\ddot{C}u\,\bar{A}^2 + \ddot{C}u\,\bar{A}q^{12}$, instead of $\ddot{C}u\,\bar{A} + 6\,Aq$.* We may add, that if the constitution of verdigris were correctly represented by the latter simple formula, it would be difficult to expect so remarkable a mobility among its constituents, that the weakest chemical force disunites then, and causes them to combine in different proportions

4. *Black Sub-acetate of Copper.*

When the soluble sub-salt is heated in a dilute solution, it deposits a flocky liver-brown coloured substance, which, when received upon a filter, washed, and dried, appears black, and soils strongly every thing with which it comes in contact. This substance passes readily through the filter, and renders the water turbid whenever we begin to wash it. If it be washed so long as the water continues to dissolve out any copper, and if the filtered liquid be evaporated to dryness, there is left upon the glass a thin, transparent, colourless film, resembling a coating of varnish. This proceeds from the brown salt, which had been dissolved by the water.

If it be prepared by boiling verdigris or the insoluble subsalt in water, the filtered liquid is more easily obtained transparent; but, in this case, a portion of the insoluble green salt always escapes decomposition, and remains, therefore, intermixed with the precipitate.

100 parts of this black subsalt dried in a temperature of 150°, on being analyzed by hydrate of barytes, and by precipitating the copper with a plate of iron, yielded from 5·6 to 5·7 parts of sulphate of barytes, and from 91·6 to 92·5 parts of peroxide of copper. In another experiment, in which the salt was decomposed with sulphuric acid, I obtained 183·95 parts of sulphate of copper = 91·46 peroxide of copper. The mean of these analyses indicates 92 per cent. of peroxide of copper, whose oxygen

* I think it probable that compounds may hereafter be formed containing a still larger proportion of hydrated oxide of copper; for in the verdigris which I prepared, I observed portions of an intense and pure dark blue colour, whose quantity, however, was too inconsiderable for purposes of an analytical examination.

is 18·55. 5·6 parts of sulphate of barytes are equivalent to 2·45 parts of acetic acid, whose oxygen is 1·151; but 1·151 × 16 = 18·416. For the water there remains 5·55, whose oxygen is 4·934: this again is only a very little more than four times the oxygen of the acetic acid, or one-fourth of that of the peroxide of copper. This salt is therefore composed of

	By experiment.	By calculation.	Atoms.
Peroxide of copper	92·00	92·30	24
Acetic acid	2·45	2·44	1
Water	5·55	5·26	12

The following is a summary of the results to which I have been conducted by the experiments detailed in this memoir.

1. Acetic acid is capable of combining with peroxide of copper in the following proportions:

1. Neutral acetate of peroxide of copper = $\dot{\dot{C}}u\ \bar{A}^2 + 2$ Aq
2. Blue verdigris. = $\dot{\dot{C}}u\ \bar{A} + 6$ Aq
3. Soluble subsalt = $\dot{\dot{C}}u^3\ \bar{A}^4 + 12$ Aq
4. Insoluble subsalt = $\dot{\dot{C}}u^3\ \bar{A}^2 + 3$ Aq
5. Black or brown subsalt = $\dot{\dot{C}}u^{24}\ \bar{A} + 12$ Aq

If the quantity of base in the neutral salt be regarded as unity, its quantity in the others, when compared with the same quantity of acid, will be found to constitute multiples of the unit by the numbers $1\frac{1}{2}$, 2, 3, and 24 (48 ?). In the first salt, the base is combined with twice as much acid as in the second; and in the third, with twice as much as in the fourth.

2. Of all these salts the second has the simplest composition, and consists, if the calculation be made directly from the weight of its component parts, of the simplest number of atoms; but it possesses a property which is directly contradictory of this supposed simplicity of constitution, for its ingredients are retained in union by weaker affinities than in any of the other combinations of acetic acid and peroxide of copper, and have a greater tendency to separate, and to recombine in other proportions. A temperature of 140° decomposes it, with the loss of a portion of its chemically combined water, into an atom of the first and an atom of the fourth salt. A sufficient quantity of cold water decomposes it into an atom of the first, an atom of the third, and two atoms of the fourth salt; and a sufficient quantity of boiling water decomposes it into a large number of atoms of the first salt, and a very few of the fifth. From all these circumstances, together with this, that in the salt the oxygen of the acid is not a multiple by a whole number, but by $1\frac{1}{2}$ of the oxygen of

the base, it appears probable that the blue variety of verdigris does not possess so simple a constitution as is indicated by the foregoing formula, but that it may be a compound of the first salt with hydrated peroxide of copper and water of crystallization; on these grounds, its composition would, perhaps, be more accurately represented by the formula $\dot{Cu}\,\bar{A}^2 + \dot{Cu}\,Aq^2 + 10\,Aq$, in the last term of which, the water of crystallization is distinguished from the portion which acts as an acid when in combination with the peroxide of copper.

Article VII.

Reply to M. Vauquelin's Remark on a supposed Contradiction in Dr. Thomson's System of Chemistry.

(To the Editors of the *Annals of Philosophy*.)

GENTLEMEN, *Glasgow, Aug.* 10, 1824.

On my return home yesterday from Berwickshire, I found the number of your journal for the present month lying on my table. My attention was naturally attracted to the notice in p. 147 translated from the Ann. de Chim. and entitled "Note on a Contradiction in Thomson's System of Chemistry respecting Phosphuretted Hydrogen Gas. By M. Vauquelin." M. V. observes, that I state in the first place that phosphuretted hydrogen contains its own volume of hydrogen united to a volume of phosphorus vapour; that when it is exposed to the direct rays of the sun, a quantity of phosphorus is deposited, and bihydroguret of phosphorus obtained; and that when sulphur is heated in bihydroguret of phosphorus, the bulk is doubled, and two volumes of sulphuretted hydrogen obtained. M. Vauquelin then goes on to show, that these two statements are inconsistent with each other, and that when sulphur is heated in phosphuretted hydrogen gas, only a very slight increase of bulk takes place. He mentions also that the deposition of phosphorus takes place without any exposure to the sun's rays, and more rapidly during the night and in a dark place than during the day.

Had M. Vauquelin paid attention to the account which I have given of bihydroguret of phosphorus in the passage of my System of Chemistry which he quotes, he would have seen the cause of the apparent contradiction which he notices. It is owing to my having supposed that phosphuretted hydrogen gas, when altered by keeping, is converted into the gas which Sir H. Davy obtained by heating hydrated phosphorous acid, and which he described in Phil. Trans. for 1812, p. 408. To this account I referred in my System, thus pointing out the source whence I

derived my knowledge of the properties of bihydroguret of phosphorus.

Davy found that the bulk of this gas was doubled when potassium was heated in it, or when sulphur was sublimed in it. He states that three volumes of it require for complete combustion more than five volumes of oxygen gas; and that it is a compound of one part by weight of hydrogen and five parts of phosphorus. Now this (when the requisite corrections are made) is the same as if he had said that it is a compound of two atoms hydrogen and one atom phosphorus. In consequence of these statements of Davy, I thought myself entitled to conclude that the gas which he described was a compound of two atoms hydrogen and one atom phosphorus, and I called it in consequence bihydroguret of phosphorus.

I had myself determined by experiment that when phosphuretted hydrogen gas is left for some time over water or mercury, it deposits phosphorus without any perceptible alteration in its bulk, loses the property of burning spontaneously when mixed with atmospheric air, and yet still continues a compound of phosphorus and hydrogen. Hence I inferred that it had become the identical gas described by Davy. But I made no experiments on the effect produced on it by potassium and sulphur, relying on the accuracy of Davy's statements.

But I still considered that it would be necessary to determine the point by direct experiments; and more than two years have elapsed since I set about examining the subject. I left a quantity of pure phosphuretted hydrogen in a graduated glass jar over mercury for six months; namely, from January to August. The mercurial trough was placed nearly in the middle of my laboratory, which is a large room, and so that the sun never shone on the gas. Another jar filled with the same gas was placed over mercury in the dark, and left for the same length of time. But it must have been accidentally overturned, and again replaced by some person; for when I examined the gas, I found it to be common air. The gas standing in the middle of the laboratory had not sensibly altered its bulk; but a portion of phosphorus had been deposited on the inside of the jar. It did not burn when mixed with common air or oxygen gas; but still had the peculiar smell which characterizes phosphuretted hydrogen gas. Its bulk was not in the least altered by subliming sulphur in it, so that in this respect (as Vauquelin states) it resembles phosphuretted hydrogen, and differs from Davy's gas. One volume of it required for complete combustion $1\frac{1}{4}$ volume of oxygen gas. When a volume of it is mixed with 0·75 volume of oxygen, and an electric spark is passed through the mixture, detonation takes place, and the oxygen disappears; but the residual gas is within one-seventh of a volume, and on adding another half volume of oxygen gas, it may be detonated again,

and the whole disappears. Thus it cannot be consumed completely by two different proportions of oxygen gas, which distinguishes it from phosphuretted hydrogen gas.

The effect produced by subliming sulphur in this gas shows that it contains its own volume of hydrogen gas. Hence the hydrogen in a volume of it will require for combustion half a volume of oxygen gas. The remaining 0·75 volume of oxygen gas must have combined with the phosphorus vapour, and converted it into phosphoric acid. Now phosphorus vapour requires for this its own volume of oxygen gas. Thus it is evident that phosphuretted hydrogen gas when left standing over mercury loses one-fourth of its phosphorus, and becomes a compound of

	Sp. gr.
1 volume hydrogen gas	0·0625
$\frac{3}{4}$ volume phosphorus vapour.	0·6250
	0·6875

So that its specific gravity is reduced from 0·9027 to 0·6875, and it contains just ten times as much phosphorus by weight as of hydrogen. It is a compound of 4 atoms hydrogen and 3 atoms phosphorus.

M. Vauquelin will see from the above statement that the gas in question is not the same as Davy's gas to which I gave the name of bihydroguret of phosphorus (a harsh term, but expressive of the composition of the gas). We may call it, for the sake of distinction, *subphosphuretted hydrogen gas.*

Thus phosphorus and hydrogen gas unite in at least three proportions; viz.

	Hydrogen.	Phosphorus.
1. Phosphuretted hydrogen composed of. ..	1 atom	+ 1 atom
2. Subphosphuretted hydrogen	4	+ 3
3. Bihydroguret of phosphorus	2	+ 1

I am, &c. THOMAS THOMSON.

ARTICLE VIII.

On an Anomaly presented by the Combination of Potassium and Oxygen; with some general Observations on Combination. By the Rev. J. B. Emmett.

(To the Editors of the *Annals of Philosophy.*)

GENTLEMEN, *Great Ouseburn, Aug.* 6, 1824.

IN estimating the specific gravity of oxygen as it exists in different solid compounds, potash presents a remarkable pheno-

menon. According to the tables in Brande's Chemistry, which seem to be generally very exact, the atomic weight of oxygen is 7·5; the atom of potassium is 37·5; its specific gravity ·85. Protoxide of potash, by the combustion of potassium in dry oxygen is 45, and its specific gravity is 2·5. Now the volume of a body $= \frac{\text{its weight}}{\text{its sp. gr.}}$.

Therefore the volume of an atom of potassium $= \frac{37{\cdot}5}{0{\cdot}85} = 44{\cdot}11$,

and the volume of an atom of dry potash $= \frac{45}{2{\cdot}5} = 18$.

The volume occupied by the atom of oxygen in this compound = volume of potash − volume of potassium = 18 − 44·11 = − 26·11; so that 37·5 parts by weight of potassium occupy a volume which may be represented by 44·11; by combustion, it combines with 7·5 parts by weight of oxygen, and the volume becomes 18; consequently the space occupied by the oxygen is negative, i. e. 26·11 of space less than 0, which is absurd. Since the above numbers are the result of the most careful experiments, the subject is of great importance, inasmuch as it is a singular anomaly, and intimately connected with the first principles of chemical philosophy. If the particles of all solids be at all times in contact with each other, as I have supposed in all my former papers, so extraordinary an effect cannot result from any known property of combination; for (as I have proved in a former paper) if a solid be heated to its fusing point, and its temperature next reduced to the true zero, the utmost possible diminution is $\frac{1}{4}$ of the original volume; or volume at the melting point : volume at zero :: 1 : $\frac{3}{4}$; and in the combination of bodies, unless their atoms be very unequal, no diminution greater than this can be produced. Therefore on this principle the effect cannot be produced.

By the generally received hypothesis, that the particles of solids are never in contact with each other, the phenomenon may appear to be accounted for; for since the attraction between the two bodies is evidently very powerful, a great diminution of volume may be supposed to take place, since there is no limit to that which may take place, except the distance between the particles, which some philosophers have supposed to be extravagantly large. But here arises a great difficulty: suppose the force of attraction to vary according to any assumed law, the simplest investigation will show that there can be no force of cohesion, unless the particles of the solid actually touch each other; that is, it is only in contact that the particles can be powerfully urged together by a force, which is indefinitely diminished, when the distance between their centers is increased by any indefinitely small quantity. This hypothesis then being opposed to every known principle of philosophy is untenable.

Boscovich has presented it under a different form, and which, if it were correct, would readily explain the phenomenon under consideration. He supposes the particles of matter to attract each other, and the force of attraction at all greater distances to be smaller than at nearer distances, and to repel each other, by reason of the elastic force of caloric, the repulsive force diminishing more than that of attraction, when the distances are increased; he supposes that upon the surface of a particle of matter, the repulsive force is greater than the other; hence at a certain distance, there will be an equilibrium, and this will be the distance of the particles from each other. Having made this supposition, he thus accounts for the force of cohesion: the particles, being at that distance from each other at which the opposite forces are equal to each other, are at rest. If a force be applied which tends to separate the particles from each other, if their distance be by it increased by the smallest quantity, an attracting force resists it, which force is called cohesion, because, since the force of repulsion varies inversely as some higher power of the distance than attraction does, beyond the distance at which there is an equilibrium, the force of attraction is greater than the other. Were this hypothesis accurate, the phenomenon might be explained; but there are many serious objections to it. When particles are balanced by the equilibrium of two opposite forces, they will constitute a liquid, but never can form a solid; because they have perfect freedom of motion round each other, will yield to every impulse, arrange themselves so as to have a horizontal surface, by the action of gravitation, and press upon the vessel containing them equally in all directions; all which are properties of liquid substances, but have no resemblance whatever to those of solids. Besides, a long rod of metal ought to be visibly stretched by a very small force, and the cohesive force ought to increase continually, until the very instant of its being overcome. Again, suppose the distance between two adjacent particles to have any assumed ratio to the diameter of either of them, in any given solid; form two equal large solids of the same substance, and suppose the force of attraction to vary as $\frac{1}{D^n}$ (D being the distance from the centre); place these at such a distance that they shall be similarly situated to the particles of the solid; then if d be the distance between two particles, since in both cases the diameters are proportional to the distances, the force of attraction between two particles : force between the spheres :: $\frac{d^6}{d^n} : \frac{D^6}{D^n}$, so that unless the attractive force vary inversely as a higher power of the distance than the fifth, the attraction between the spheres must be very great; for although no force is visible at the distance d, since the forces are equal and opposite at that distance, the forces must

be very great, if so vast an effect as that of cohesion be their difference, when d is very little increased; and since the repulsive force is corpuscular, and cannot operate between the large spheres, the force must inevitably be enormously great, if the hypothesis be true; but none whatever is observed.

Again: according to this hypothesis, take away the force of repulsion, and that of attraction is very great, at a distance equal to the distance between two adjacent particles; increase this distance (by breaking the solid) and the force totally vanishes; break rods of glass or other brittle matter at different temperatures; the same effect results; but at different temperatures, the particles are at different distances from each other; therefore this force of attraction ceases to operate at different distances, although the weight of the body does not vary. Nothing need be said to prove that no such force is known to exist; it is totally unlike any force of which we can form an idea; for let a force vary inversely as any power or function of the distance, the only place where a body can attract another in such a manner that by increasing the distance by the smallest quantity, the force shall vanish or be indefinitely reduced, is on the surface; but here we have to suppose one at a distance, which cannot result from a variation according to any function whatever of the distance (except the force increase directly as some power of it, then cohesion would be produced at an infinite distance), and this is not the only difficulty, for we have to suppose this distance to be moveable. Hence this hypothesis is more untenable than the other. Therefore we must suppose the particles of solids to be in contact with each other, and upon this hypothesis it is impossible to see how the phenomenon in question can be produced; in fact, there is no parallel. In no case of combination, where one of the bodies is solid, do we meet with a condensation nearly so great as in this instance. Even were we to suppose the particles of solids not to touch each other, the condensation so very much exceeds that which takes place in every other case, that we should naturally expect to find some peculiarity in potassium, which gives rise to the anomaly, which certainly appears to favour the supposition that potassium is a compound of hydrogen and a base hitherto unknown. However, future experiments only can ascertain the cause of so singular a phenomenon; and until experiments point out the cause, whatever is supposed at present must be very uncertain and unsatisfactory.

Article IX.

An Account of some Observations made during a late Aerial Excursion. By Capt. Beaufoy, Coldstream Guards.

(To the Editors of the *Annals of Philosophy*.)

GENTLEMEN, *London, July* 31, 1824.

I do myself the pleasure of forwarding you an account of some observations which I made during a late aerial excursion; and if you should think it worthy of insertion in the *Annals of Philosophy*, I cannot but feel much flattered at such a circumstance. I have the honour to be, your obedient servant,

Mark Beaufoy.

On Thursday, the 17th of last June, at five minutes past six in the evening, the balloon rose from the gardens of White Conduit House, Islington; the barometer being then 29·8 inches, the thermometer 66°, and the hygrometer 17° dry. Wind very high from the north.

I felt no motion whatever! All objects seemed to sink from the car; and in a short time quite lost their altitude.

At eight minutes past six, the barometer was 27·4 inches, or 2257 feet, thermometer 46°, hygrometer 15° dry, when every thing was perfectly distinct, but flat like a military map; and at twelve minutes past six, barometer 25·5 inches, or 4235 feet, thermometer 45°, we passed through some thin mist. The balloon soon after entered a different current of air, which caused it to make about half a revolution, slowly; occasioning a slight sensation of sickness, that went off in one or two seconds, when the machine became steady.

At sixteen minutes past six, barometer was 23·3 inches, or 6605 feet, thermometer 39°, hygrometer 20° dry, when the machine became enveloped in clouds; which were by no means dark, nor had the approach to them been gratifying. Soon after a disagreeable sensation of singing in the ears was felt by Mr. Graham and myself, and continued the whole voyage; the application of cotton not removing it.

Until this moment, every thing had been distinctly visible from the balloon; trees, houses, ships, &c. had length and breadth, but no height. Roads seemed like footpaths of an orange-colour, fields of corn as if ruled with lines of vivid green; the hedges looked thicker and darker.

On rising above the clouds, a most magnificent sight met the eye! One vast expanse of frozen snow, with enormous masses towering above the rest like mountains, having every summit

burnished by the rays of the sun, which shone most brilliantly from a sky of a deep-blue colour.

At twenty minutes past six, barometer 21·6 inches, or 8608 feet, we heard the report of a cannon, but no reverberation after it; and the balloon again revolved gently.

At twenty-six minutes past six, when the barometer was 20·2 inches, or 10,416 feet, another gun was heard; and the clouds below rolled over each other into the most fantastic shapes, while between their fissures the earth was clearly discernible.

At thirty-one minutes past six, barometer 19·5 inches, or 11,298 feet, thermometer 32°, hygrometer 25° dry, I let loose a pigeon, which flew away with ease and rapidity, its wings making a great noise from the perfect stillness around. After one or two circles, it darted through an opening in the clouds; and I was assured by the owner that it reached its nest in the City-road at twenty minutes past seven o'clock the same evening.

At twenty minutes to seven, barometer 19·2 inches, or 11,711 feet, thermometer 32°, hygrometer 31° dry, Mr. Graham judged we were as high as we could ascend without throwing out ballast; and as we were far above every object interesting to the eye, the cord of the valve was slightly pulled, and we commenced an extremely gradual descent. At this elevation, 757 feet higher than Mount Etna, I heard the report of a gun, and could distinguish the metropolis when clouds did not intervene. The balloon seemed to be over Kennington, and I found nothing disagreeable in looking about, except at objects perpendicularly under the car.

At eighteen minutes to seven, the barometer was 19·5 inches, or 11,271 feet, and thermometer 31°; when our descent was so imperceptible, that it could only be ascertained by throwing out very little bits of silver paper; and I in vain endeavoured to find out from the compass the direction the balloon was taking; as though the needle pointed north, it could not tell whether we floated to or from that point.

At nine minutes to seven, the barometer was 22·3 inches, or 7784 feet, thermometer 38°, and hygrometer 23°, when we approached the clouds; which had a most beautiful effect from the masses of vapour seeming to rise up in eddies to meet us.

At five minutes to seven, barometer 24 inches, or 5822 feet, the machine was quite enveloped in a thick mist, which, at four minutes to seven, barometer 24·5 inches, or 5263 feet, became dark; and gave rise to an unpleasant feeling, of floating in space without any defined objects to rest the eye on. The voice also appeared much weaker and lower than at any other period of the voyage; but I did not feel any oppression at the chest, as I coughed two or three times on purpose to ascertain whether it pained me.

At seven o'clock, barometer 25 inches, or 4714 feet, we

emerged from the clouds; and getting into a new current of air, the balloon turned round again. At three minutes past seven, barometer 26·5 inches, or 3130 feet, every object on the earth became perfectly distinct; and Mr. Graham let down his grappling iron, at the end of a cord 160 yards long.

At seven minutes past seven, barometer 28·3 inches, or 1385 feet, thermometer 50°, hygrometer 22° dry, the height of houses and trees became apparent; and one minute afterwards, the grapple having caught in the boughs of an oak, brought the car to the ground with considerable violence; and after rebounding two or three times, Mr. Graham and myself stepped out without any difficulty into a field near Godstone.

In this aerial excursion, I was much surprised to find the atmosphere become drier as we ascended, except only at the height of 2257 feet. After our descent, I had occasion to use my handkerchief, when the sound in my ears was like the report of a pistol.

The balloon was 63 feet high, by 37½ in diameter, which lemon-shaped figure contains 46,388 solid feet; and as each cubical foot of common air equals 1⅕ oz. the whole weighed 3479 lbs. But the inflammable air used, was 2½ lighter than common air; therefore,

⅗ of 3479 = 1392 lbs. weight of gas
630 lbs. weight of silk, car, aeronauts, &c.

2022 lbs. total weight suspended,

which, deducted from 3479 lbs. gives 1457 lbs. for the power of rising.

Now the highest point we attained was 11,711 feet, at which elevation the density of the air is ·652; and by calculation, it appears, we might have reached 14,142 feet without lightening the machine at all; but if 150 lbs. had been thrown out, to the height of 16,146 feet, or rather more than three miles.

It does not seem probable that any individual was ever raised in a balloon much beyond this last point. First, because that belonging to Mr. Graham, in which I ascended, is larger than those generally used; and secondly, the inflammable air becomes so much distended in the rarer atmosphere above, that a great deal escapes out of the safety valve, and more is expended in accomplishing the descent; so that on approaching the earth, the balloon collapses, and falls with an alarming rapidity.

It is true that many balloons are supposed to have reached a far greater elevation; and one French gentleman was particularly fortunate in that respect. But, perhaps, the gas he used

to inflate the silk was seven or eight times lighter than common air, which would of course make a great difference; though as the second objection of the machine collapsing on approaching the earth could not be got rid of, I am apt to believe him wrong in his calculations.

ARTICLE X.

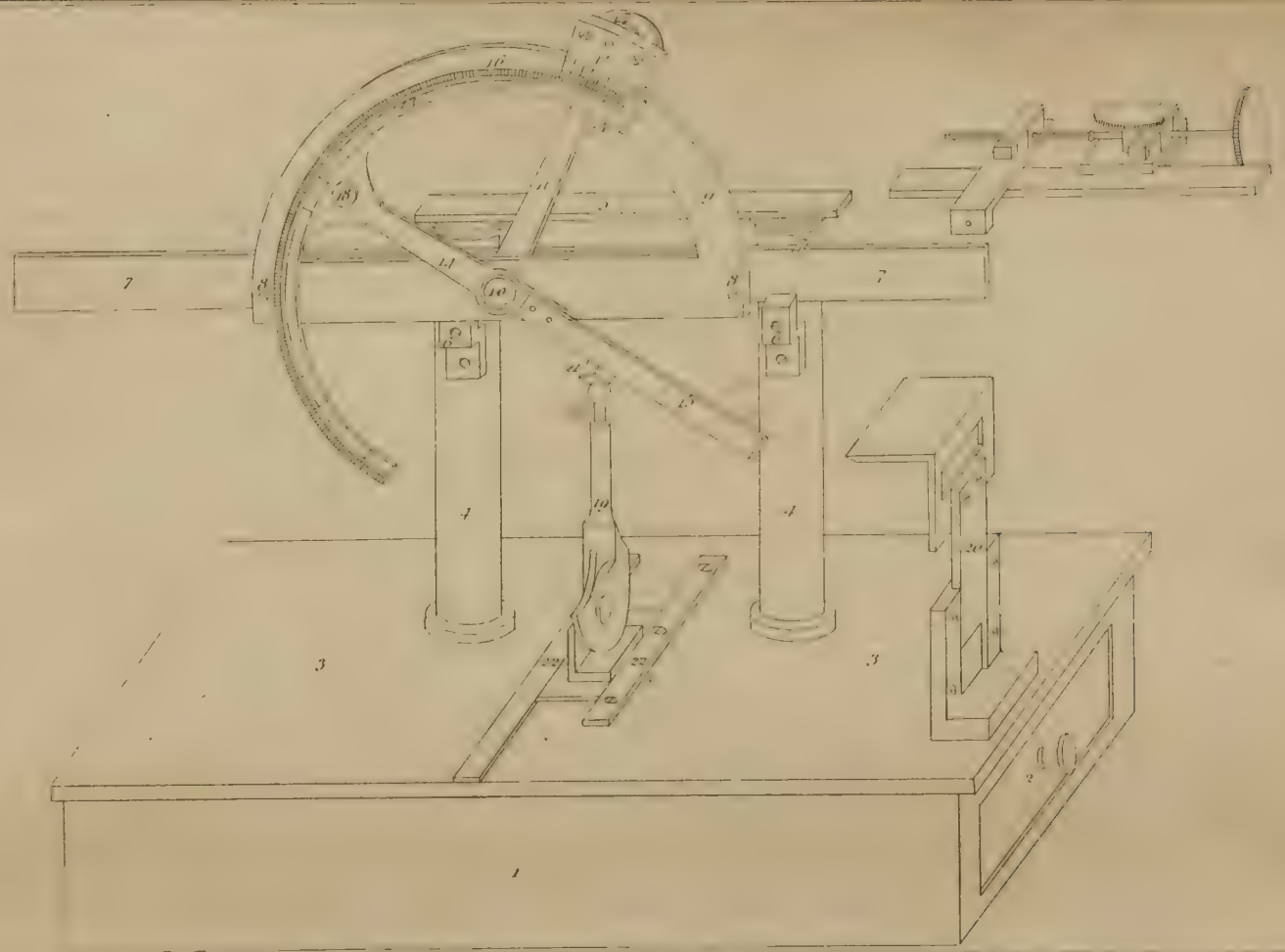
*Description of the improved Goniometer of M. Adelmann.** (With a Plate.)

THE first goniometer was that of Carangeot, which was made under the direction of Romé de Lille, who may justly be regarded as the father of crystallography. This instrument (the only one ever used by Haüy) was much improved by M. Gillet de Laumont, who increased the size of the semicircle, and made the divisions more sensible, but still it partakes of the imperfections of the original instrument. One of these consists in the difficulty of placing the two legs of the instrument perfectly perpendicular to the edge which unites the two planes of a crystal, whose angle of incidence we wish to measure; another in placing them on the faces of the crystal, so that the whole flat surface of the legs, and not merely their edges, shall touch the face of the crystal in every point, without which it is impossible to obtain an accurate measurement.

"The reflective goniometer, for which we are indebted to Dr. Wollaston, to whom the sciences owe so many other obligations, is a much more perfect instrument, but it requires conditions in the crystals to be measured by it, not easily met with; such as perfectly plane faces, free from striæ, and sufficiently brilliant to reflect the light in such a manner as to present a distinct image of the lines of observation. If we attempt to measure a crystal with this instrument, whose faces are striated, however slightly, which unfortunately is but too commonly the case, or which are not perfectly flat, we may be certain of obtaining results more or less inaccurate—a circumstance which it seems to me has already often occurred.† I admit, however,

* Extracted from the Memoir of M. Le Comte de Bournon.

† The author of the Review of the third edition of Phillips's Mineralogy (Journal of Science, vol. xv. p. 324) seems to entertain very different notions of the merits of the reflective goniometer from those of Count Bournon. The review contains a copy of Mr. Phillips's elaborate figure of a crystal of humite, selected, says the author, "first, because its form has never been described before;" secondly, Count Bournon, in his Catalogue, says, that "*all its planes are striated*, whereas *not one of them is so; for what he mistook for striæ, are, in fact, so many planes, as has been proved by subjecting the crystals to the reflective goniometer;* thirdly, it shows, therefore, the value of that instrument in a striking degree, and that the use of it quickens the sight of the observer, who, while measuring without a glass, *finds planes*, where an old, and generally supposed accurate observer saw only striæ."—J. G. C.


7
7
4
4
3
3
1

that as this instrument can only be destined (*ne peut être destiné*) to establish the primitive form, the type of all those which the observed object can present, and which serves as the basis for calculating all the secondary faces, a single crystal of the substance, although very small, which fulfils all the necessary conditions, would be sufficient; still, however, some secondary planes are requisite to determine the dimensions, and, in a great number of substances, especially if they do not admit of a perfect and easy cleavage, such a crystal is yet to be sought for."

"M. Adelman's goniometer has none of the inconveniences of the instruments I have mentioned, and, moreover, possesses advantages which in them are wanting. I consider that I shall do a service to the science by describing it, and the manner of using it."

The instrument consists of a small mahogany box, (1) see Plate XXX, eleven inches long, six wide, and three high, containing a drawer (2). The top of the box (3) is covered with a plate of brass, at least two lines thick, to prevent its springing, and to render the base sufficiently heavy. The rest of the instrument is made of brass. Two pillars (4), nine lines in diameter, and at least four inches and a half high, are fastened to the brass plate, at the distance of three inches from each other, and are united and fixed at the upper end by a plate (5). At the top of each column is a box (6) in which a steel rule (7), seven lines wide and one line thick, moves horizontally; the rule is placed edgeways, in order to render its motion more smooth and regular. For the same purpose, each box has a roller at the bottom, on which the rule slides. A semicircle (8) is fixed to the rule by its diameter, the length of which is six inches, four lines, and its broad part (9) seven lines wide. The semicircle is not in contact with the moveable rule, but separated from it by an interval of about three lines. This interval is necessary on this side of the semicircle, in order to adapt to the other extremity of its axis (10) the moveable radius (11), which, at its upper end, carries the nonius (12). On this first semicircle, which is fixed, is placed a second, divided into degrees, minutes, and half minutes, which, from its size, are perfectly distinct. The second semicircle (13) is fixed by its radius (14) to the centre of the first, and is moveable; but its motion on the fixed semicircle is perfectly smooth, and free from jirks. The radius of the moveable circle is produced beyond the centre, by a steel arm (15) adapted to it, which may be called the measuring radius. The part (16) of the fixed semicircle is necessary to enable the moveable nonius to travel round the moveable semicircle. A screw (17) placed behind the nonius serves to fix it at pleasure; (18) is a button for moving the graduated semicircle.

Two detached pieces are added to this instrument; one of

them (19) is a support with a hinge, to receive at its upper extremity the crystal to be measured (21); this support slides in a groove (22) in order to bring it nearer to, or further from, the measuring radius, or to withdraw it altogether. The other (20) is a sight-vane, by means of which we can ascertain, after the crystal is fixed on its support, if the edge which separates the two planes, whose incidence is to be measured, be in a perfectly horizontal position.

To use the goniometer, we place the crystal on the support, in the position just mentioned, then slide the support along the groove, till the measuring radius lies exactly above it, and turn the graduated moveable semicircle, having previously removed the nonius (12) that its motion may be unobstructed. The rest of the operation consists in placing the arm of the measuring radius very accurately on the plane of the crystal, which is opposed to it. This is done by moving the rule (7) to which the semicircle is fixed; and to do this more easily, and avoid jerks, it is necessary to use both hands, one placed at each extremity of the rule.* If the radius be not placed exactly on the face of the crystal, it is to be gently withdrawn, in order to elevate or lower the moveable semicircle, which is to be done in like manner, by using both hands, seizing with one the extremity of the measuring radius, and with the other, the opposite extremity of the moveable circle, till the measuring radius lies so evenly on the face of the crystal, that no day-light can be seen between them when examined with a lens. That done, the moveable nonius (12) is lowered till it meets the stop (23) placed at zero of the moveable semicircle, and fixed by the screw (17). The support is then to be withdrawn, in order to pass the measuring radius on the other side of the crystal, when it is replaced, and the business finished, by repeating on that face of the crystal the same operation as was performed on the other. The value of the angle of incidence of the two planes, in degrees and minutes, is then read off on the graduated semicircle and its nonius.

The instrument is represented in the figure as having finished its operation on one of the faces of the crystal, and with the nonius fixed.

The use of this goniometer is very easy; it has the advantage of being fixed, and of not depending for the accuracy of the observations on the manual dexterity of the observer; nor does it require that perfect brilliancy of surface, in the crystal to be measured, which it is often so difficult to find. As the measuring radius, when once placed on the face of the crystal, remains

* A regulating screw, with its carriage, was at first used to adjust the motion of the rule, as shown in the figure, at the place where it was fixed; but it was found not to be necessary, as the adjustment can be made quite as accurately, and much more quickly by hand, provided the rule itself, and the rollers on which it slides, be made perfectly true.

fixed in that position till the obverser changes it, if his eyes be fatigued by the operation, he can leave it as long as he pleases, and examine the accuracy of his work at a future occasion, or have it verified by an assistant. The great condition necessary, is that the faces of the crystals be perfectly plane, which unfortunately is not always so easily fulfilled as might be wished.

Article XI.

Remarks upon Mr. Daniell's Work on Hygrometry.

(To the Editors of the *Annals of Philosophy*.)

As none of the Scientific Journals in their notices of Mr. Daniell's work on Hygrometry make any remarks on a part of that work which, if I mistake not, is erroneous, I beg leave to direct the attention of your readers to the subject.

A principal object with Mr. Daniell, is the application of his improvements to the correction of the barometer when that instrument is used for ascertaining the heights of mountains; but it is not a little surprising that he should have erred in his manner of computing what is commonly the greatest and most important correction required in using the instrument.

That to which I allude, is the compensation for difference of temperature at the two stations, which Mr. D. considers as a case of *apparent* dilatation of the mercury, and gives, for the purpose of correction, a table calculated by Mr. Rice, from the results of Dulong and Petit's experiments: now, besides that the last mentioned gentlemen are egregiously wrong in their way of deducing the apparent expansion, it is not only inapplicable to the present case, but is as a standing number quite useless for every other purpose, varying as every one knows.

It has always been understood that, other circumstances being alike, mercury in the barometer will have its altitude affected by the existing temperature in no other way than as that temperature alters its *specific gravity*; so that whether the tube expand or contract, or were it possible, do neither, whatever the material of which it is made, whatever its sectional form, equality or inequality of calibre, still the *absolute* dilatation and not the apparent must regulate the correction for difference of temperature.

After a detailed account of the many operations gone through by Mr. Daniell and his fellow-labourer Mr. Newman, while making a barometer for the Royal Society, during which every thing is done to attain accuracy, we are told that "a scale is engraved on the front, of the correction to be applied for the dilatation of the mercury *and the mean dilatation of glass*, by which the observation may be at once reduced to the standard

temperature of 32°;" that is to say, the barometer for the use of the Royal Society so carefully made, is to have its observed height corrected for temperature, by using the constant denominator 11,664 (64·8 × 180) for each degree of Fahrenheit, or by Mr. Rice's table. This number, however, has no connexion with the computation in question, for seeing that Mr. D. is partial to Dulong and Petit, their number 9990 (55·5 × 180) ought to have been Mr. Daniell's choice; and with regard to the mean dilatation of glass, repeated so *mal à propos*, D. and P. take no mean whatever, asserting its uniformity, and besides do not deduce the number which Mr. D. ought to have used from any such consideration, but on the contrary and conversely, use that number and the apparent dilatation falsely taken, to *find* that of glass, where they again err.

At pages 358—9 examples are given for the various corrections, but all those for temperature are on the same erroneous principle as that engraved on the instrument; and previously, page 183, there occurs one where $\frac{1}{50}$ seems to be taken as the fraction of dilatation. This example I profess not to understand, unless it be intended to show that we may take any number at random for this correction.

In taking the liberty of making these remarks on Mr. Daniell's meritorious work, it may be admitted that, though he and Mr. Rice have inadvertently assumed $\frac{1}{6\,4\cdot8}$ as the fundamental number on a false principle, still it may not be so far from the truth as it might have been, since the absolute dilatation of mercury is given so variously, that in adopting the right principle, Mr. Daniell might have a number still more erroneous.

Important as a knowledge of the real amount of the dilatation of mercury would be, in many scientific determinations, in none perhaps is it of such consequence as in this correction for the mountain barometer, respecting which, nevertheless, there is too much cause for regretting that, even in this age of refined experimental knowledge, we are so embarrassed with conflicting authorities, as to be forced to entertain more than a suspicion that the real quantity is still unknown. Mr. Dalton calls it $\frac{1}{5\,0}$; Dulong and Petit $\frac{1}{5\,5\cdot5}$; and General Roy $\frac{1}{5\,9}$; while philosophers, of equal and undoubted reputation, vouch for the authenticity of almost every intervening denominator, and some for even a greater.

If such be the actual state of our knowledge with regard to the quantity of the absolute dilatation of mercury, it is difficult to conceive how Mr. Daniell can so confidently assert, that "this effect has been most minutely appreciated, and its correction applied with the utmost ease and precision." M. Biot fixes this number at $\frac{1}{5\,4\cdot1\,8}$, which is generally received in France, and by many here; yet even this celebrated philosopher is wrong, by having made a false conclusion from his own pre-

mises, Traité, tome i, page 52. From what he there states, a different number ought to have been obtained; and the error affects many of his subsequent formulæ relating to the barometer, expansion of fluids, of gases, &c.

In common with many others, Mr. D. seems to think that boiling the mercury in the tube of a barometer is of great consequence; this is at least doubtful, but certain it is that no human art can render a mass of this fluid such *mere* mercury that it shall not contain something, which in all its mechanical effects may not be called air. Sir H. Davy is in the right when he says so; and it is not a little to his credit to have perhaps by induction inferred that such is the fact, when there is no reason to think him aware of certain proofs to which it were needless here to appeal.

Mr. Daniell speaks also of filtering the mercury; though performed a thousand times no good effect can follow this practice. A knowledge of this metal gained from a peculiar application of it, warrants the assertion, that the mercury of commerce is not improvable by either distillation or filteration, in so far as its application is purely mechanical, and that its fitness for barometers can be completely known by bare inspection.

There is a probable source of error in the barometer hitherto little attended to, and of which Mr. D. takes no notice; in making the correction for temperature, it has ever been taken for granted, that the expansion proceeds *pari passu*, or that the fraction of dilatation is, for example, the same from — 20 to — 30, as it is from 90 to 100. This is, however, quite a gratuitous assumption; and although there are reasons for here suspecting something different from the utmost degree of precision, it is possible that the experimental means which we at present possess are inadequate to ascertain any appreciable discrepancies.

Much learning has been brought to bear on the other corrections requisite in using the mountain barometer; and Mr. Daniell could not have conferred a more substantial benefit than by having set the question at rest, as to the absolute dilatation of mercury, without a certain knowledge of which, all other minute attentions are little better than mere drivelling.

Mr. Daniell's account of the manufacture of barometers and thermometers is most certainly not overcharged. Throughout the continent, and even in England, the business is in the hands of itinerant Piedmontese; and these artists supply not only the general public with their glittering baubles, but furnish the greater part of the most reputable instrument-makers with their whole stock of meteorological wares. Such of these as choose to graduate their own scales, must confide entirely as to the quality of their tubes and the excellence of the filling, in one who has but indirect interest in the matter, or equivocal

reputation to lose; responsibility is thus shuffled from both, and rests on neither. Such, however, are the people who by unaccountable prescription supply the city of London, and the philosophers of England, with the instruments which Mr. Daniell so well describes.

If common notoriety did not bear Mr. Daniell out in his assertions, the shameful disagreement of the thermometers used by Captain Parry in his last voyage, would fully do so. On one occasion this amounted to no less than 13 degrees; Capt. Parry could do nothing else than give a mean, though in such a case — 48° had as good a *chance* of being the truth as — 35°. X.

Article XII.

Instructions for the Assay of Chloride of Lime. By M. Gay-Lussac.*

The uncertainty which has hitherto existed in the modes of ascertaining the quality, and consequently the commercial value of chloride of lime, and in no small degree retarded its coming into general use, has determined me to publish the following instructions on the subject. I shall divide the work into two parts; in the first I shall expose the principles on which the assay of the chloride of lime is founded, and in the second I shall describe the instrument which I call a *Chlorometer*, and the manipulations necessary for making the assay with sufficient accuracy for the purposes of those arts in which chlorine is employed.

Part I.

Principles on which the Assay of Chloride of Lime by means of Indigo is founded.

It is known that chlorine destroys vegetable colours, by forming new compounds with their component principles. It is in consequence of this property which it possesses, whether in the state of gas, in solution in water, or in combination with an alcali, that it is employed in the arts of bleaching, calico printing, &c. The same quantity of chlorine, in either of those three states, destroys the same quantity of colouring matter; and since by combination with an alcali, it becomes fixed, has scarcely any smell, keeps better, is more portable, and more capable of concentration, the advantages of preparing it in that form are obvious.

Caustic potash, soda and lime, and even their carbonates, combine very readily with chlorine. Its combination with the

* From the Annales de Chimie.

potash, or soda of commerce, has long been known in France by the name of *eau de javelle;* that with lime was called oxymuriate of lime; but it is more accurate to denominate the first, as is now generally done, chloride of potash or soda, and the latter chloride of lime.

The chlorides of potash, soda, and lime, have very little stability of composition; the two first, indeed, can only be obtained in the liquid state, in a large quantity of water. If, for instance, we pass chlorine into a concentrated solution of potash, at first chloride of potash will be formed; but this chloride will soon be decomposed, and converted into *chlorate of potash*, and *chloride of potassium*. The two latter compounds, not having the property of destroying colours, must be avoided, and the only means of preventing their formation is to employ a very weak solution of the alcali, which, at most, should not exceed the proportion of 125 grammes to a litre of water. (In round numbers, about $4\frac{1}{2}$ oz. potash to $2\frac{1}{4}$ pints of water.)

Lime has not, like potash and soda, the inconvenience of converting the chlorine into chloric acid; it may consequently be combined with the chlorine *en masse*.

Lime, if perfectly dry, does not absorb chlorine, but it combines with it rapidly when in the state of hydrate, that is, after it has imbibed a sufficient quantity of water from a moist atmosphere, to split and fall to powder. Supposing it to be in the state of hydrate, it forms, according to M. Welter, a sub-chloride only, which is composed of

2 proportions of	lime	$= 2 \times 35{\cdot}603$	=	71·206
2	water	$= 2 \times 11{\cdot}2435$	=	22·487
1	chlorine		=	44·2653
				137·9583

When mixed with water it is immediately decomposed; one half of the lime is precipitated, and the other half remains in solution, combined with the whole of the chlorine, and consequently forming a neutral chloride. Hence there are two combinations of chlorine with lime, a sub-chloride, and a neutral chloride. The sub-chloride is obtained by saturating hydrate of lime with chlorine, and the neutral chloride by dissolving the sub-chloride in water, or by saturating lime, dispersed through water, with chlorine.

The neutral chloride, or more simply the chloride, is very soluble; it may, however, be made to crystallize in small prisms. Its solution, left in contact with the air, is gradually decomposed, one part of the lime combines with the carbonic acid of the atmosphere, whilst its chlorine is disengaged. This decomposition of the chloride is retarded by constantly keeping an excess of lime in the solution. From these properties of the

chloride, the advantage of manufacturing the sub-chloride only is obvious; its preservation and transport are much more easily effected.

The quantity of chlorine in combination with water, or a base, may be estimated by several processes; but in the arts, in which dispatch is important, the preference has been given to M. Descroizilles' process, founded on the property of chlorine to discolour indigo. One part of indigo dissolved in 9 parts of concentrated sulphuric acid, and then diluted with 990 parts of water, forms the coloured liquid usually employed to ascertain the quality of the chlorine.

Under the same circumstances, chloride of lime discolours a quantity of this solution proportionate to its own; but if they vary, the results also are very variable. Thus, if we pour the chloride *slowly* into the indigo, a much smaller quantity of it is necessary to effect the discoloration than if we proceed differently. The minimum of discolouring effect, is obtained by pouring the indigo very slowly into the chloride, and the maximum by pouring the chloride very slowly into the indigo. Repeated trials have proved that the best process for obtaining constant and comparable effects, is to pour the solution of indigo *rapidly* into the solution of chloride, or the latter into the former. I shall explain the mode of operating by and bye.

If the indigo of commerce were pure, or always of the same quality, the quantity of its solution employed in each assay would give the relative quality of the chloride; but since its quality is very variable, the results of trials made with different indigos cannot be compared together. To avoid these inconveniences, I have followed the example of M. Welter, and taken as unity of discolouring power that of pure, dry, chlorine, at the barometrical pressure of 0·76 m. (29·92 inches,) and temperature of 0°. (32 Faht.) I prepare a solution of any of the best indigos of commerce of such a strength that the chlorine discolours exactly ten times its volume of it, and I call this solution the *proof tincture;* and each volume of proof tincture that is discoloured I call a *degree*, and I divide the degree into ten parts.

Thus, if we take 10 grammes* of chloride of lime and dissolve it in such a quantity of water as to form 1 litre of solution, the number of degrees, or volumes of indigo discoloured by one volume of the solution of chloride, will indicate the number of tenths of a litre of chlorine that the solution contains. Consequently, 1 kilogramme† of chloride of lime, whose quality had been determined by this method, and found to be of 7·6° or $\frac{76}{100}$ths, would contain 76 litres of chlorine. Each degree therefore is equal to 10 litres, per kilogramme of chloride, and each tenth of a degree to 1 litre. Supposing the sub-chloride

* Or 1 decagramme, Tr. † Or 100 decagrammes, Tr.

of lime to be perfectly pure, and formed as stated in page 219, it contains per kilogramme 101·21 litres of chlorine.

The base I have adopted appears to deserve the preference, from the simplicity and precision of expression that it admits of in chlorometry, which may remain unchanged, whatever means may be used to measure the strength of the chlorine.

We obtain more precision in general with a weak solution of chloride, marking for instance 4 or 5 degrees, than with a very concentrated solution. If, therefore, on the first trial we find that the chloride much exceeds 10°, we must add a known volume of water to the solution, for instance, twice its bulk; we then make a fresh trial, and triple the number of degrees obtained to get the true value of the chloride.

Assay of the Oxide of Manganese.

The purity of the oxides of manganese, employed in preparing the chlorine, is very variable, and consequently that of any particular ore must be ascertained by experiment, which may be easily done in the following manner.

Pure peroxide of manganese is formed of,

Manganese	3·5578 grammes
Oxygen	2·0000
	5·5578

and furnishes 4·4265 gram. of chlorine, or 1·3963 litre, at the temperature of 0°, and under a pressure of 0·76 m; consequently 3·980 gram. would produce 1 litre of chlorine, and 1 kilogramme would produce 251·23 litres.

We take, therefore, 3·98 gram. of the oxide of manganese which we wish to assay, and treat it with muriatic acid, with a gentle heat, receiving the disengaged chlorine in rather less than a litre of milk of lime; towards the end of the operation we make the acid boil, to drive the chlorine from the vessels into the milk of lime, and add water to make its quantity just one litre. The quality of this chloride will exactly give that of the oxide of manganese.

The value of the manganese does not depend wholly on the quantity of chlorine it is capable of furnishing, but also on that of the muriatic acid required for its production. But the operation is delicate, and the low price of muriatic acid makes it unnecessary. I shall only remark, that the peroxide of manganese often contains the carbonates of lime, barytes, and iron, which saturate to mere loss a portion of the muriatic acid; moreover, as the manganese is not always in the state of peroxide, the quantity of muriatic acid required will not in that case be proportionate to that of the chlorine obtained.

PART II.

Description of the Chlorometer, and of the Method of proceeding in the Assay of the Chloride of Lime.

A. (Plate XXXI.) Small balance.

B. Weight of 5 grammes.

C. Mortar to pulverize the chloride of lime; by this operation we ensure greater accuracy in the assay, as the chloride often contains lumps which dissolve slowly.

D. Jar, with a foot, containing exactly half a litre when filled to the circular line *m*, terminated by two opposite arrows; the *surface* of the water must coincide with this line, and not its upper edge, which is indicated in the figure by the dotted line. The jar must be placed on a horizontal table.

E. Stirrer, to stir the solution of the chloride and make it homogeneous: it is to be plunged down into the liquor, and raised up again, alternately, without being taken out of it.

F. Small measure, or tube, of $2\frac{1}{2}$ cubic centimetres, which is unvarying for the chlorometer in question; it is intended to measure the solution of chloride of lime. To fill this tube, it is plunged into the chloride to just above the circular line *n*, which terminates its capacity, and the chloride made to rise in it by suction; when filled, the fore finger, which should neither be too dry nor too wet, is placed on the upper orifice, the tube raised out of the liquid, and its lower extremity supported against the margin of the jar, as seen at G, or against the finger. By a little management of the pressure, and a slight alternate circular motion of the stem between the fingers, the liquid descends slowly, and when the lower part of the concave curve which terminates it is in the plane of the little circular line, the stream is immediately stopped, by increasing the pressure and the tube emptied into the drinking glass H.*

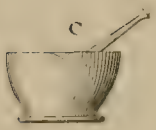
H. Large drinking glass for mixing the indigo proof tincture with the chloride. It should be placed on a sheet of white paper, in order more easily to observe the changes of colour which the indigo undergoes by the action of the chlorine.

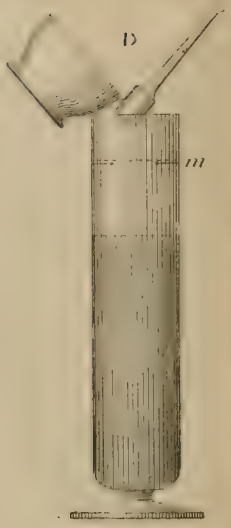
I. Tube for measuring the proof tincture: each great division, or degree, is equal to the capacity of the small tube F, and is divided into 5 parts, which is sufficient for practice; but for calculation, the fifths are reduced to tenths. This tube is filled with the proof tincture up to the degree 0, which is easily accomplished, by putting into it rather more tincture than is necessary, and pouring off the excess, drop by drop, by the beak, the extremity of which should be covered by a slight layer of wax or tallow, to assist the running off in drops.

* When the tube becomes opaque, it is cleared by dipping it in muriatic acid, or vinegar.

























J. Sharp, Sc.

Engraved for the Annals of Philosophy for Baldwin, Cradock & Joy, Sept. 1st 1824.



K. Another tube graduated like I, but in a contrary direction. Its use is to hold the proof tincture which is to be poured briskly into the chloride. For conveniently obtaining the desired volume of the tincture, the tube L, drawn out to a point at its lower end, is employed; the excess of tincture is removed by plunging the tube to the necessary depth into it, and closing the upper orifice with the finger before it is withdrawn; in the same manner a deficiency may be supplied from the vessel containing the indigo.

Preparation of the Solution of Indigo, and of the Proof Tincture with that Solution.

Take a determinate quantity of indigo, sifted through a silk sieve, put it in a matrass with nine times its weight of concentrated sulphuric acid, and heat it in a water-bath, at the temperature of boiling water, for six or eight hours. Dilute a part of this solution with such a quantity of water that 1 volume of chlorine may discharge the colour of exactly 10 volumes of the solution: this will be the proof tincture. The simplest, and at the same time sufficiently accurate method of preparing a liquid containing its own volume of chlorine, is to take 3·98 gram. of well crystallized manganese, and treat it with muriatic acid, receiving the chlorine in milk of lime, whose volume is to be reduced to that of 1 litre after the operation, as mentioned in the assay of the oxides of manganese; but if we wish to operate with the utmost accuracy, the chlorine must be prepared in the state of gas, and absorbed by water in which a little lime has been infused; the temperature, pressure, and moisture of the gas being noted.

Important Observation.

The proof tincture, being gradually discoloured by light, must be carefully kept secluded from it in stone jars; but for the use of the chlorometer it may be preserved in a half litre glass phial, always taking care not to expose it to the direct rays of the sun: it had better be kept in a dark closet.

Process of Assaying the Chloride.

Take several specimens from the mass of chloride to be examined, and weigh off 5 grammes, and pound them in the mortar, with a sufficient quantity of water to make thin cream; then dilute it with more water, and decant it into the half-litre jar. In order not to lose any liquid in this operation, rest the edge of the motar against the pestle, as seen in the figure D. Triturate the residual chloride remaining in the mortar with water, and decant as before, and repeat these operations till no more is left in the mortar. Rince it out and pour the rincings

into the jar. Make up the volume to exactly half a litre, and stir it to render it perfectly homogeneous. Fill the tube (I) with proof tincture up to 0°, and pour a portion of it, less than that which you suppose will be discoloured by the chloride, into the glass H, for instance, 5°.

Take one measure of chloride in the small tube F, and make it flow quickly into the proof tincture, by blowing into the tube, agitating the mixture the whole time. If the tincture be completely discoloured, add quickly from the tube I, such a further quantity as to give the liquid a slightly greenish colour; the quantity of proof tincture taken from the tube I, will be the measure of the quality of the chloride, provided the second portion added be not considerable, nor amount to three-tenths of a degree.

But if the second portion of proof tincture added to the chloride, exceed the quantity of three-tenths of a degree; if, for instance, it amount to 1·2°, the assay must be begun again. Fill the tube I with the tincture, and pour as much of it into the glass H, as is equal to the quantity discoloured in the former experiment, and some hundredths over. Then complete the operation in the manner already described. The assay has not attained the utmost precision it is capable of, till the proof tincture assumes the slightly greenish tint, *immediately* on the chloride being added, without a fresh quantity being required.

By these successive operations we approach as near as we please to the true quality of the chloride; nevertheless, I do not think that we can in general be certain of it beyond $\frac{1}{50}$th. These operations may, perhaps, appear complicated, but I must remark, that each of them may be executed in two or three minutes; that when we previously know pretty nearly the quality of the chloride, two operations are sufficient, and that in the current labours of a manufactory one assay will be enough. Moreover, the object is to ascertain the quality of the chloride, in order to fix its commercial value, and in that case we must not be niggards either of our time or our pains.

The same process is directly applicable to the assay of a solution of chlorine in water; but it is better to begin by adding a little powdered quick-lime to the liquid to convert it into chloride.

The tube K, which forms part of the chlorometer, is intended for assaying the chloride, by pouring the indigo quickly into the chloride. For this operation the quantity of tincture required to saturate one measure of chloride must be previously ascertained by the tube I.

The assay is then begun again by putting into the tube K, a quantity of tincture equal to that which has been discoloured, and a small quantity over, which must be poured quickly into a fresh measure of chloride; as much tincture must then be added

as is necessary to give the greenish colour, and the assay once more renewed by putting into the tube a quantity of the tincture, equal to that discoloured in the preceding assay. The manipulations of this experiment are precisely the same as those of the first; but since the results are similar, and it requires the tubes K and L in addition, I do not consider it as preferable to the former.

It may be convenient to some of our readers if we reduce the French weights and measures employed by M. Gay-Lussac, in the preceding very valuable paper to equivalent English ones.

100 cubic inches of pure dry chlorine, at the mean pressure and temperature of 30 inches and 60° Faht. weigh 75·375 grains, 1 volume of which discolours 10 volumes of the *proof tincture*.

Suppose we take 250 grains of chloride of lime and dissolve it in 100 cubic inches of water, and that we find the value of this solution to be denoted by 7·6°, or, in other words, that 1 cubic inch of the solution discolours 7·6 cubic inches of proof tincture; then the whole quantity, or 100 cubic inches of the solution of chloride, would discolour 760 cubic inches of tincture, one-tenth of which, or 76 cubic inches, is the quantity of chlorine it contains.

250 grains = $\frac{1}{28}$th of a pound avoirdupois; consequently, 1 lb. of chloride of lime of the above quality would afford $(28 \times 76) = 2128$ cubic inches of chlorine, or rather less than $1\frac{1}{4}$ cubic foot, or about 138 cubic feet per cwt.

Assay of the Oxide of Manganese.

Pure peroxide of manganese is composed of

Manganese	28 grains
Oxygen	16
	44

and affords 36 grains of chlorine, or 47·76 cubic inches at mean pressure and temperature; consequently 92·127 grains will give 100 cubic inches, and 1 lb. will give 4·397 cubic feet.

We take therefore 92·127 of the oxide to be assayed, and treat it as directed, p. 221, receiving the disengaged chlorine in rather less than 100 cubic inches of milk of lime, which, after the operation, must be made exactly equal to that quantity by pure water, and assayed as above. The result will indicate the quality of the oxide of manganese in cubic inches of chlorine per 92·127 grains of ore.

To coincide with these weights and measures, the small weight B should be equal to 125 grains: the capacity of the jar G to the arrows, 50 cubic inches, and that of the little measure or tube F, $\frac{2}{10}$ of a cubic inch. Each of the large divisions on the tubes I and K, must also be equal to $\frac{2}{10}$ of a cubic inch, to correspond with the capacity of the small measure F,

To prepare the liquid containing its own volume of chlorine, instead of the 3·98 grammes, &c. p. 221, we must take 92·127 grains of well crystallized oxide of manganese, and receive the chlorine in 100 cubic inches of milk of lime; and in the process of assaying the chlorides, (p. 223) we must employ 125 grains of the mixed salts, and decant the solutions into the 50 cubic inch jar D. J. G. C.

ARTICLE XIII.

Corrections in the last Number of the Annals.

(To the Editors of the *Annals of Philosophy*.)

GENTLEMEN, *Aug.* 18, 1824.

PERMIT a constant reader to point out a few oversights that occur among the Scientific Notices in the last number of the *Annals of Philosophy*, viz. for August.

Your candour, added to your wish to render the journal as free from error as possible, will find an excuse for the liberty now taken.

1. In Article 4, p. 140, where the table exhibiting the quantity of each chalybeate preparation containing 1 grain of oxide of iron is given, the numbers that ought to have been attached to Ferri Subcarbonas and to Ferrum Ammoniatum are transposed, and thus absurdly erroneous quantities are set down for these substances.

2. The title of Article 5, p. 140, is erroneous, "On the Use of *Nitrous Oxide* in Eudiometry." It ought to be *Nitric Oxide*.

3. Article 8, p. 151, "Inflammation of Sulphuretted Hydrogen by Nitric Acid." In this title, as well as in the description of the experiment, I apprehend that you have substituted nitric for nitrous acid.

The experiment is not a new one, and it is not due to Berzelius. I remember well having seen it above twelve years ago in the lectures on chemistry in the University of Edinburgh, and I am certain that Dr. Hope made use of strong fuming nitrous acid. It may be mentioned by the way that the exhibition is remarkably striking and brilliant when made on a large scale.

To the best of my recollection, the Professor, instead of using a flask containing four or five cubical inches of gas, as recommended by Berzelius, employed a large wide-mouthed receiver of nearly 200 cubical inches capacity, and poured into it about half an ounce of the strongest fuming nitrous acid, covering the orifice slightly with a piece of paper.

The explosion is not violent, but the flame in the interior of the vessel is beautiful.

I remain, Gentlemen, your obedient servant, A. B.

We thank our friend A. B. for his good opinion of our can-

dour, and for the trouble he has taken in pointing out our errors. We hope they are not unpardonable.

A. B. is right as to the transposition of the two salts of iron. It should be 1 grain in 66 of ferrum ammoniatum, and 1 in 1·2 of ferri subcarbonas.

The erratum respecting nitric oxide has been already marked for correction. The third error, if one, does not originate with us; the article is copied *verbatim* from the Journal of Science. —C.

Article XIV.

Proceedings of Philosophical Societies.

ROYAL ACADEMY OF SCIENCES OF PARIS.

The Royal Academy of Sciences of Paris not having adjudged the prize proposed in 1822 to any of the memoirs delivered in, decreed in the sitting on the 7th of June last, that the same subject shall be proposed afresh for the prize for 1826, viz.

1. *To determine by multiplied experiments the density which liquids, particularly mercury, water, alcohol, and sulphuric ether, acquire by pressures, equal to the weight of several atmospheres;* and

2. *To measure the effects of the heat produced by those pressures.*

The prize is a gold medal of the value of 3000 francs.

The subject for the mathematical prize for 1826, is,

A method for calculating the disturbances of the elliptical motion of comets, applied to the approaching return of the comet of 1759, *and to the motion of that observed in the years* 1805, 1819, *and* 1822.

The prize is a gold medal of the value of 3000 francs.

Both these prizes will be adjudged in the public sitting on the first Monday in June, 1826; and the memoirs must be sent in before the 1st of January of that year.

The subject for the prize in the class of natural history, for 1825, is,

To determine by a series of chemical and physiological experiments, the nature of the phenomena which successively occur in the digestive organs, during the process of digestion.

The candidates will first ascertain the chemical, or other modifications which the immediate organic principles undergo in the digestive organs, particularly those which enter into the composition of food, as gelatine, albumen, sugar, &c.

Their researches will next be directed to the alimentary substances themselves, in which several immediate principles are united, carefully distinguishing between liquid and solid aliments.

The experiments must be pursued in the four classes of vertebrated animals.

The prize is a gold medal of the value of 3000 francs, to be decreed in the public sitting on the first Monday in June, 1825.

The memoirs must be sent to the Secretary of the Institute before the 1st of January in that year.—(Annales de Chimie.)

Article XV.

SCIENTIFIC NOTICES.

Chemistry.

1. *On the Means of detecting the Presence of Acetate of Morphia, in Animals poisoned by that Substance.* By M. Lassaigne.

The process adopted by M. Lassaigne is as follows:—The contents of the stomach, or the fluid ejected from it, were filtered, the fluid carefully evaporated, and treated with boiling alcohol of the specific gravity of ·837, which separated the animal substances. The alcoholic solution was evaporated to the consistence of an extract, and treated with distilled water, to separate the fatty matter; the solution was then filtered, and deposited, by a gentle evaporation, prismatic crystals at the bottom of the capsule, which possessed the following properties.

They had a bitter taste, and were precipitated in white flakes from their solution in water by ammonia; treated with concentrated sulphuric acid in a small glass tube closed at one end, they exhaled a decided odour of acetic acid: they immediately give a yellow solution with nitric acid, which, with an increased quantity of acid, deepened to orange, and afterwards exhibited a fine reddish-yellow, blood colour.

These characters belong to the acetate of morphia, and amply attest the presence of that substance. To free the alcoholic extract from colouring matter, M. Lassaigne poured acetate of lead into its solution in water (as practised by Pelletier in his experiments on strychnia), which threw down the colouring matters, and left the morphia and the excess of precipitant in the supernatant liquid, which was easily cleared of the latter by a few bubbles of sulphuretted hydrogen gas. The solution was then evaporated in vacuo over a surface of sulphuric acid, and the fixed alkaline substances were thus obtained free from colour derived from any foreign matter. The action of nitric acid then readily demonstrated by its orange-red colour the presence of the acetate of morphia.

On examining the stomach, intestines, heart, and blood of a cat poisoned by 12 grains of the acetate, the morphia was only detected in the stomach. The thoracic cavity of a dog which

died in 10 minutes after the injection of 14 grains of the poison, contained acetate of morphia, as did also the small intestine of a cat, and the duodenum of a dog, after the poison had been injected into those parts.

Thirty-six grains of acetate of morphia were injected into the crural vein of a dog, and 30 grains into the jugular vein of a horse, but none could be detected in the blood, drawn 1¼ hour after injection from the opposite vein; but on repeating the experiment, and bleeding the animal in 10 minutes after the poison was injected, it was found in the blood.

M. Lassaigne concludes from his experiments,

1. That in many cases of poisoning by acetate of morphia, sensible traces of that vegetable poison may be chemically detected.

2. It is always found in the viscera in which it was first deposited.

3. The contents of the stomach, ejected by vomiting soon after the injection of the poison into it, contain ponderable quantities of the acetate of morphia.

4. All attempts to detect its presence in the blood of animals poisoned by acetate of morphia, have been ineffectual.—(Journ. de Pharmacie.)

2. *Cause of the Odour of Hydrogen Gas.*

In our last number we quoted some observations by Berzelius respecting the oil which communicates to hydrogen gas, its peculiar odour: as the circumstance, although well known to chemists, has been seldom adverted to, we shall lay before our readers a brief account of some facts which had been previously ascertained respecting it.

About the year 1800, Proust stated, in a memoir read before the National Institute, that this peculiar odour resides in a volatile aromatic oil, of a bituminous flavour, which is held in solution by the gas; and in support of his opinion, he adduced the following facts. 1. During the solution of cast iron in sulphuric or muriatic acid, the neck of the retort, and the sides of the receiver, have a greasy appearance, in consequence of their being coated with minute drops of this oil. 2. When a considerable quantity of metal is dissolved at once, as from 12 to 15 oz., drops of this oil are obtained floating on the liquid in the receiver. 3. The carbonaceous matter remaining after the digestion of cast iron in either of these acids, yields a portion of this oil by distillation: alcohol also extracts the oil from it, and the solution is rendered milky by the addition of water. —(Mem. Pres. à l'Inst. des Scien. i. 205.)

Vauquelin, about five years after, confirmed the preceding observations, and communicated some additional information respecting the properties of the oil. He prepared it by dissolv-

ing cast iron in dilute sulphuric acid, and digesting the residue in very strong alcohol: the solution was filtered while hot, and the alcohol was distilled off with a very gentle heat. Thus obtained, the oil was clear and transparent, had a slight lemon-yellow colour, and an acrid taste. It appeared to hold a middle rank between the fat and volatile oils. He remarked the formation of a similar oil during the solution of tin in muriatic acid.—(Journal des Mines, No. cxix. p. 392.)

Doebereiner ascertained more recently that hydrogen gas may be rendered completely inodorous, by being kept in contact for some time with newly ignited charcoal—(Schw. Journ. iii. 377)—and Mr. Donovan, that the same object may be effected by passing the gas successively through lime water, nitric acid, solution of green vitriol, and water. Neither of them alludes to an oil as occasioning the peculiar odour: the latter, indeed, ascribed it wholly to sulphuretted and phosphuretted hydrogen.—(Phil. Mag. xlviii. 138.)

Before concluding, we may observe, that although this oleaginous principle is probably formed invariably during the solution of the sub-carburets of iron, and also of other metals, such as manganese, nickel, &c. which combine with small quantities of carbon, there are besides other circumstances under which the hydrogen evolved during the solution of metals will possess a peculiar odour. This will take place whenever the metals contain traces of phosphorus, sulphur, selenium, tellurium or arsenic. The solution of those varieties of iron, so common in France, which contain phosphorus, is always accompanied with the odour of phosphuretted hydrogen. Most of the tin which occurs in commerce, even those refined specimens sold under the name of grained tin, occasion the evolution of a considerable quantity of sulphuretted hydrogen gas when dissolved in muriatic acid. We think it not improbable that the doubtful compound described by Kastner and others, under the name of stanniuretted hydrogen gas, is nothing else than arseniuretted hydrogen; which, of course, must make its appearance whenever the tin happens to be contaminated with arsenic. This would account for the prejudicial vapours which are occasionally emitted during the solution of tin in muriatic acid, and which are so much complained of by those who prepare solutions of muriate of tin on a large scale, for the use of the dyer and calico printer.

3. *Selenium, an Attendant of Sulphur.*

Pleischl (in Schweigger's Neues Journ. ix. 348,) expresses his *opinion* that selenium is not an uncommon attendant of sulphur: we are inclined to think, from the observations of Berzelius, Stromeyer, Gmelin, Wähler, Lewenau, &c. that the fact is already pretty satisfactorily established.

A foreign admixture of this nature would account for the very deleterious qualities which the French chemists ascribe to sulphuretted hydrogen gas, and for their antipathy against inhaling the slightest particle into the lungs. (Thenard, Traité de Ch. 3d edit. i. 722—729.) That the odour of the gas is sufficiently unpleasant must be admitted; but we have repeatedly remained in atmospheres copiously impregnated with it, without experiencing any injurious consequences, and we do not hesitate to assert, that the antidote which they recommend, namely, the continual emission of chlorine into the open air so long as the gas is preparing, is a much more serious inconvenience than the one which it is intended to correct. It can scarcely be doubted, that their sulphur contained either selenium or arsenic; and as Thenard has described this extremely noxious quality as one of the inseparable characteristics of sulphuretted hydrogen gas, it appears probable that the contamination is far from unfrequent.

Mineralogy.

4. *A Superb Collection of Minerals for Sale.*

Dr. Joseph Guillaume Waagner, of Vienna, has announced the sale of the superb collection of minerals, late the property of M. Jacques Frederick Von der Nüll, deceased.

This collection is well known, both for the magnificence of the specimens, and by its having been arranged and described by Professor Mohs, in 3 vols. 8vo. Vienna, 1804.

When that work appeared, the collection contained 3926 specimens, exclusive of the cut precious stones which form a valuable collection by themselves, and do not belong to the great collection. Since that time, to the death of the owner in May 1823, the cabinet has been continually increasing, and the number of specimens it now contains amounts to 5047, of which 3427 are ticketted with numbers corresponding with M. Mohs' catalogue, and the remaining 1620 are briefly described in a catalogue by M. Partsch.

The average size of the specimens is about three in. by two, and they are contained in three cabinets of 48 drawers each. The specimens of gold, silver, and tellurium, and the minerals in general found in the Austrian empire, particularly Hungary and Transylvania, are said to be remarkably fine.

The price is fixed at 3000*l.* sterling, and time will be allowed for payment on satisfactory security being given.

Persons wishing to treat for the purchase, are requested to apply to Dr. J. G. Waagner, Hohenmarkt, No. 511, 3 ème étage.

5. *New Locality of Tellurium.*

During a recent arrangement of the collection of minerals belonging to the Royal Academy of Sciences of Stockholm, there

were observed several specimens of a broad foliated mineral from Riddarhyttan, having a silver-white colour, and the metallic lustre. Berzelius instantly recognized it as being identical in its external characters with the mineral first described by Von Born, under the name of molybdenous silver, which Klaproth considered as a sub-sulphuret of bismuth, but which he himself ascertained a few years ago to be an alloy of bismuth and tellurium, mixed with some selenium. (The Use of the Blowpipe, Eng. Tr. p. 152.) The mineral from Riddarhyttan proved by a blowpipe examination to contain rather more sulphur than Von Born's, but the other constituents appeared to be exactly the same, and in exactly the same proportions in both. It is remarkable as being the first instance in which this rare metal has been found in Sweden.—(Kongl. Vet. Acad. Handl. 1823, st. I.)

MISCELLANEOUS.

6. *Hydrophobia cured by Acetate of Lead.*

Dr. Fayerman, of Norwich, had a patient under his care, labouring under the most dreadful symptoms of confirmed hydrophobia, in consequence of the bite of a mad dog upwards of three months before he was taken ill. Having tried the usual methods without success, Dr. Fayerman, to use his own expression, "took time to consider what was best to be done; my personal observations confirmed me in the previous idea which I had entertained, that *hydrophobia is a disease specifically of the nervous system. I felt more strong in the belief, from the knowledge that local irritation from wounds in irritable habits, especially when conjoined with a perturbed state of the passions, and also violent affections of the mind, independently of corporal injury in hysterical and hypochondriacal constitutions, have at times produced all the pathognomic symptoms of canine madness.*" "Having witnessed the powerful effects of lead on the nervous system, I determined at once to give this mineral a trial in the terrific disease before me." "At nine o'clock," (the patient being in a state of comparative quiet, from exhaustion) "I gave him 35 drops of the *liquor plumbi superacetatis*, vulgo *Goulard's extract of lead*, on a lump of sugar; the pulse at this period was tremulous and irregular, and at 105; the power of deglutition at this period was greatly impeded by the frequent spasms affecting the glottis, and it was at least 15 minutes before the medicated sugar had passed into the stomach. At 10 o'clock the dose was increased, and he took 40 drops of the *extract of lead*, in the same manner as before, pulse 98. He slept from half-past 10, to within a few minutes of 11. He was awoke by severe pain about the scrobiculus cordis, great thirst and heat about the fauces, but there was absence of

spasmodic contraction which had previously threatened suffocation. At one o'clock, on the 13th of August, I repeated the venesection eight ounces, and gave 45 drops of the extract of lead, mixed in a small portion of honey. At three, this morning, the dose was repeated, and notwithstanding the powerful astringency of the medicine, there was certainly less difficulty in the act of swallowing. The pain about the stomach had been reduced in violence, since the use of the lancet a second time, and the mind had become more calm and collected. At five o'clock the thirst having increased beyond endurance, he expressed a desire to drink; a little weak brandy and water, mixed in a tea-pot, was presented to his notice; but the moment the fluid had been taken to the lips, a violent spasm came on, he seized the vessel with the fury of a maniac, and bit the spout off. In 25 minutes after this paroxysm had subsided, 50 drops of the solution of lead was administered. At nine o'clock the patient complained of coldness along the spine, and of a peculiar tingling sensation in the lower extremities, and soon after of total inability to move his limbs—the pulse at this time was at 84. I examined his legs and found them completely paralyzed. The *symptoms of hydrophobia became every hour after this crisis materially lessened.* I fully succeeded at half-past 10 in getting down three tablespoonfuls of castor oil. I reduced the solution of lead in doses of 20 drops every three hours; at 12 o'clock the bowels were evacuated; at two P. M. we again attempted the introduction of the weak brandy and water, the patient made a bold and resolute effort to conquer or die in the struggle. He armed his mind with the strongest courage and fortitude; he carried the vessel to his lips, and although his countenance fully displayed the most horrid repugnance, yet from a total absence of spasm, he succeeded in getting down a considerable portion of the fluid. From this moment I considered the cause gained, and I hailed with joy the triumph which such a conquest inspired. I gradually descended the scale of my remedy to 10 drops, and I had the satisfaction to find, that *in the space of* 48 *hours from the first exhibition of the solution of lead in this case of hydrophobia, all the more urgent symptoms of this monstrous disease had abated.* In four days, not the *least appearance of hydrophobia malady* existed, the patient had the look of a person enervated and debilitated to an excessive degree; the wound in the hand" (occasioned by excision of the bitten part, and the application of caustic,) "was suffered to remain open for some weeks. On the 26th September, the patient recovered the use of his limbs and was discharged."

(Signed) ARNALL THOMAS FAYERMAN.

We have extracted the preceding from the account which

appeared in the Morning Herald of the 7th of last month. It cannot be too generally known; for if further experience prove the efficacy of the remedy, Dr. Fayerman's name will stand deservedly high, as a benefactor of mankind. The subject is rather more exclusively *medical*, than we are in the habit of admitting amongst our *miscellanea*, but our great object is to make the pages of the *Annals of Philosophy*, the medium for communicating interesting and useful matter in every department of science, to the world at large, whether that matter be original, or selected from respectable cotemporary journals, foreign or domestic, and other works of merit and reputation; and we shall continue to pursue that object, equally indifferent to the worthless praises and contemptible criticisms of hebdomadal quacks and sciolists.

7. *Extraordinary Tide.*

About 10 p. m. on Tuesday, the 13th inst. wind ESE. light airs and variable; barometer 30·0, thermometer 70, a sudden flux of the tide was observed at this port, which rose several feet, and in its reflux, aided by the ebb, its rapidity was such as to sweep every thing before it. The chain conductor of the flying bridge on the Lairy, gave way, and for a time rendered its bridge useless; but by the exertions of the men it was soon repaired. However, about one o'clock, it being then near low water, the same occurrence again took place, and the bridge was again torn from its position. Boats, timber, &c. were swept away by the great flux and reflux of the tide, which continued at intervals until four o'clock on Wednesday morning (being about three-quarters flood), when it began to assume a more formidable and terrific appearance. The ordinary velocity of the tide being not more than two knots per hour, was now observed to run from seven to eight, at intervals of from 13 to 15 minutes, and sometimes 20 minutes. As the time of high water approached, the flux and reflux was more powerful, and of longer duration, probably occasioned by the unfinished ends of the Breakwater being at that time overflowed. From nine till about twelve o'clock, the river of Catwater was impassable, excepting by taking advantage of going with the current, and the same in returning. Boats were torn off the shore, and in a few moments hurried out of sight. The appearance of the elements now was truly wonderful; distant claps of thunder, heavy lowering clouds, some rising in different positions, and others floating in a horizontal direction, occasioned, no doubt, from the extraordinary variations of the wind blowing fresh in puffs from every quarter of the compass in a short space of time, with intervals of calm. Some idea of the extraordinary rapidity of the current may be imagined, when it is asserted, from the minutest observations, that the flux or *fresh* of the tide at

times, was 2 feet 2 inches perpendicular in five minutes, and again actually made a reflux of 3 feet 6 inches in the same short space of time, tearing up the soil from the bottom of the river, the agitated thick surface of which resembled the boiling of a pot. The vessels at the Breakwater one minute were afloat, and the next lying high and dry on the body of the works; and but for the great exertions of the workmen and crews, much damage must have been done. Indeed, was there a possibility of lifting that stupendous structure from its position only for an hour, not a ship could have been safe either in *Plymouth harbour* or in the *Pool!* and although it must appear strange, at the same time the sea in the offing was particularly smooth. About half-past two, p. m. the tide began to resume its regular course. No doubt we shall soon hear of some extraordinary convulsion of nature in some part of the world. In 1798, a similar occurrence took place, about the time of the dreadful earthquake in Sienna, which swallowed up many thousands of our fellow creatures.—(Plymouth Journal.)

8. *Unequal Distribution of Heat in the Prismatic Spectrum.*

That the different portions of the prismatic solar spectrum possess different heating powers, has been universally admitted by every philosopher who has examined the subject experimentally; but a great diversity of opinion has prevailed respecting the precise point where this power resides in its greatest intensity. Landriani, one of the first who investigated this subject, placed the maximum heating power in the yellow rays, Rochon in the orange or orange yellow, and Senebier also in the yellow. Herschel, on the contrary, found the heating power of the red to be superior to that of all the other coloured rays; but that there is a certain point of the spectrum, situated immediately beyond the red and invisible, which elevates the thermometer still higher than any of the visible rays. His experiments were directly contradicted by Leslie, but were soon after in a great measure confirmed by Englefield. Dr. Seebeck, in a memoir read to the Royal Academy of Sciences in Berlin, which with numerous original experiments combines a copious discussion of the opinions of preceding inquirers, appears to have ascertained the cause of those anomalous statements. It exists in the particular nature of the medium by which the rays of light are decomposed; a circumstance so little regarded that few experimenters have even deemed it necessary to record the material of their prism. The following is a summary of his results.

In every part of the prismatic spectrum, there is a perceptible elevation of temperature, and this is uniformly least in the outermost edge of the violet. From the violet it gradually increases, as we proceed through the blue and green, into the yellow and red. In some prisms, it attains a maximum in the yel-

low, as, for example, in those filled with water, alcohol, or oil of turpentine. In others, as in those filled with a transparent solution of sal ammoniac and corrosive sublimate, it attains a maximum in the orange. Prisms of crown glass and of common white glass have the maximum of temperature in the centre of the red; others, which appeared to contain lead, have the maximum in the limit of the red. Prisms of flint glass have the maximum beyond the red. In all prisms, without exception, the temperature regularly diminishes from beyond the red; but it still continues perceptible at a distance of several inches from the extremest limit of that side of the visible spectrum. (Schweigger's Nenes Journal, vol. x. p. 129.)

9. *Distinction of Positive and Negative Electricity.*

Positive and negative electricity may be readily distinguished by the taste, on making the electric current pass by means of a point on to the tongue. The taste of the positive electricity is acid; that of the negative electricity is more caustic, and, as it were, alkaline. *Berzelius.*—(Journal of Science.)

10. *Description of two Surfaces composed of Siliceous Filaments incapable of reflecting Light, &c.*

The surface was produced by the fracture of a large quartz crystal, two inches and a quarter in diameter, of a light smoky colour, but impervious to the light, except in small pieces. The surface of the fracture is absolutely black, and was at first supposed to have been occasioned by the interposition of a thin film of opaque and minutely divided matter that had insinuated itself into a fissure of the crystal; but this opinion was overturned when Dr. Brewster observed that both surfaces were equally and uniformly black. He therefore suspected the phenomenon to be occasioned by the surfaces being composed of short and slender filaments of quartz, of such exceedingly minute diameter, as to be incapable of reflecting a single ray of the strongest light; and he verified his conjecture by plunging the fragment in oil of anniseeds, which approaches to quartz in its refractive powers, and examining the light reflected at the separating surfaces of the oil and the quartz. The blackness disappeared; and the fragment, whether seen by reflected or transmitted light, comported itself like any other piece of quartz of the same translucency. On removing the oil from the surface it assumed its original blackness.

Dr. Brewster calculates the diameter of the fibres to be about $\frac{1}{3,000,000}$th of an inch, or one-fourth of the thickness of the aqueous film of a soap bubble previous to its bursting.—(Edin Jour. of Science.)

Article XVI.

NEW SCIENTIFIC BOOKS.

PREPARING FOR PUBLICATION.

In a few days will be published "Commentaries on the Diseases of the Stomach and Bowels of Children;" by Robley Dunglison, MD. &c. &c.

The papers printed in the Transactions of the Royal Society during the last three years, detailing the Discoveries of the Functions of the Nerves, will be immediately republished with Notes, and a general Introductory View of the Nervous System; by Mr. Charles Bell, Professor of Anatomy and Surgery to the Royal College of Surgeons, and Surgeon to the Middlesex Hospital.

The Topography of all the known Vineyards; containing a Description of the Kind and Quality of their Products, and a Classification. From the French. 12mo.

The Travels of General Baron Minutoli in Lybia and Upper Egypt; in 8vo.

Columbia: its present State of Climate, Soil, Productions, Population, Government, Commerce, &c. &c.; by Col. Francis Hall, Hydrographer in the Service of Columbia. 8vo.

A Practical System of Algebra for the Use of Schools and Private Students; by Peter Nicholson and J. Rowbotham.

Illustrations of Conchology, according to the System of Lamarck, in a Series of Engravings; by E. A. Crouch.

The Century of Inventions of the Marquis of Worcester, from the original MSS. with Historical and Explanatory Notes, and a Biographical Memoir; by Charles F. Partington, of the London Institution.

The Brewer's Director; a Chemical, Experimental, and Practical Essay; by a London Brewer.

JUST PUBLISHED.

Historia Rievallensis, containing a Dissertation on the Animal Remains lately found in the Cave at Kirkdale, with original Thoughts on the Geological Evidence of it, &c. &c. With Plates, from Drawings by J. Jackson, RA. 13*s.* Boards.

Principles of the Kantesian or Transcendental Philosophy. By T. Wirgman. 8vo. 6*s.*

Observations on the Rebuilding of London Bridge. By J. Seaward. 7 Plates. 8vo. 12*s.*

Iron Bridges of Suspension now erecting over the Strait of the Menai, at Bangor, and over the Conway. By J. G. Cumming. 5*s.* sewed.

Bland's Elements of Hydrostatics. Crown 8vo. 7*s.*

Shute's Principles of Medical Science and Practice. Part I. 8vo. 18*s.*

Herculanensium Voluminum, Pars Prima. Royal 8vo. 1*l.* 5*s.* 6*d.*

Hirnschadel's Encephalology. 12mo. 5*s.*

ARTICLE XVII.

NEW PATENTS

J. Gibson, woollen-draper and hatter, Glasgow, for manufacturing an elastic fabric from whalebone, hemp, and other materials combined, suitable for making into elastic frames, or bodies, for hats, caps, and bonnets, and for other purposes.—June 15.

W. Bally, the younger, Lane End Staffordshire Potteries, for his improved gas consumer, for the more effectually consuming the smoke arising from gas burners or lamps.—June 15.

J. Hobbins, Walsall, Staffordshire, ironmonger, for his improvements in gas apparatus.—June 22.

H. Austin, Alderley Mills, Gloucestershire, manufacturer, for certain improvements on shearing machines.—June 22.

J. B. Higgon, Gravel-lane, Hounsditch, for his improvement in carving-knives and other edged tools.—June 22.

W. Busk, Broad-street, merchant, for certain improvements in the means of propelling ships, boats, or other floating bodies.—June 29.

W. Pontifex, the younger, Shoe-lane, coppersmith and engineer, for his improved modes of adjusting or equalizing the pressure of fluids or liquids in pipes or tubes, and also an improved mode of measuring the said fluids or liquids.—July 1.

J. L. Bradbury, Manchester, Lancashire, for his mode of twisting, spinning, or throwing silk, cotton, wool, linen, or other threads or fibrous substances.—July 3.

P. Taylor, City-road, engineer, for certain improvements on steam-engines.—July 3.

J. L. Higgins, Oxford-street, for certain improvements in the construction of the masts, yards, sails, and rigging of ships and smaller vessels, and in the tackle used for working or navigating the same. —July 7.

W. Hirst and J. Wood, both of Leeds, manufacturers, for certain improvements in machinery for raising or dressing of cloth.—July 7.

J. C. Daniell, Stoke, Wiltshire, clothier, for his improved method of weaving woollen cloth.—July 7.

C. Phillips, Repnor, Kent, for certain improvements on tillers and steering wheels of vessels of various denominations.—July 13.

C. R. Baron de Berenge, Target Cottage, Kentish Town, for certain improvements in the method of applying percussion to the purpose of igniting charges in fire-arms generally, and in a novel manner, whereby a reduction of the present high price of fire-arms can be effected, and the priming is also effectually protected against rain or other moisture.—July 27.

A. Nesbitt, Upper Thames-street, broker, for a process by which certain materials may be manufactured into paper or felt, which material is applicable to various useful purposes.—July 27.

T. Wolrich Stansfeld, Leeds, merchant, for certain improvements in power looms, and the preparation of warps for the same.—July 27.

E. Cartwright, Brewer-street, Golden-square, engraver and printer, for improvements to roller printing presses.—July 27.

Article XVIII.

METEOROLOGICAL TABLE.

1824.	Wind.	Barometer. Max.	Barometer. Min.	Thermometer. Max.	Thermometer. Min.	Evap.	Rain.
7th Mon.							
July 1	S W	29·95	29·70	73	55	—	10
2	S W	29·72	29·70	76	46	—	05
3	N W	29·84	29·72	72	54	—	26
4	N W	30·08	29·84	66	46	—	02
5	N W	30·08	29·98	72	54	—	09
6	E	29·98	29·98	66	56	—	02
7	W	30·10	29·98	70	56	—	04
8	W	30·10	30·05	77	61	—	
9	S W	30·05	29·98	82	55	·90	—
10	N W	30·17	30·05	75	49	—	
11	W	30·17	30·17	80	55	—	
12	S W	30·15	30·08	84	53	—	
13	N W	30·08	30·01	88	56	—	
14	Var.	30·01	29·95	85	59	—	63
15	S W	30·18	29·97	77	55	·95	
16	N W	30·32	30·18	77	55	—	02
17	N	30·34	30·32	77	53	—	
18	N	30·51	30·34	74	49	—	
19	S W	30·51	30·46	75	49	—	
20	N	30·46	30·33	74	51	—	
21	N	30·34	30·33	78	54	·78	
22	E	30·33	30·29	78	50	—	
23	S	30·29	30·03	82	54	—	
24	N E	30·03	29·94	78	52	—	
25	N W	29·97	29·97	77	54	—	
26	E	30·12	29·97	73	52	—	30
27	N E	30·37	30·12	68	44	—	
28	N E	30·37	30·21	78	42	·95	
29	E	30·21	29·84	78	44	—	
30	N E	29·84	29·76	75	44	—	
31	E	29·82	29·76	76	56	·40	15
		30·51	29·70	88	42	3·98	1·68

The observations in each line of the table apply to a period of twenty-four hours, beginning at 9 A. M. on the day indicated in the first column. A dash denotes that the result is included in the next following observation.

REMARKS.

Seventh Month.—1. Fine. 2—4. Showery. 5. Fine. 6. Cloudy, with showers. 7. Showery. 8, 9. Cloudy and fine. 10—12. Fine. 13. Fine: sultry. 14. Sultry: some thunder at intervals, with large drops of rain, during the day. About nine, a tremendous storm of thunder, lightning, and heavy rain: the lightning extremely vivid, and almost continuous from the NW to the SE by the S: the thunder abated between eleven and twelve; but the lightning was visible for several hours after. 15. Cloudy and fine. 16—22. Fine. 23. Sultry. 24, 25. Fine. 26. Cloudy: showery. 27. Cloudy. 28—30. Fine. 31. Cloudy: showers.

RESULTS.

Winds: N, 4; NE, 4; E, 5; S, 1; SW, 6; W, 3; NW, 7; Var. 1.

Barometer: Mean height

For the month	30·088 inches.
For the lunar period, ending the 18th	29·954
For 13 days, ending the 1st (moon north)	29·810
For 14 days, ending the 15th (moon south)	30·006
For 13 days, ending the 28th (moon north)	30·248

Thermometer: Mean height

For the month	64·435°
For the lunar period	63·166
For 31 days, the sun in Cancer	63·322

Evaporation	3·98 in.
Rain	1·68

Laboratory, Stratford, Eighth Month, 23, 1824. R. HOWARD.

ANNALS

OF

PHILOSOPHY.

OCTOBER, 1824.

Article I.

On a new Mineral Substance. By Mr. A. Lévy, M.A. of the University of Paris.

(To the Editors of the *Annals of Philosophy.*)

GENTLEMEN, *Newman-street, Oxford-street, Sept.* 17, 1814.

Mr. Heuland had put aside a long time since a specimen of Mr. Turner's collection, from the Bank mines, in the government of Ecatherineburgh, in Siberia, considering the small emerald green transparent crystals which are upon it as differing from any described substance. Upon detaching and measuring some of them, I have ascertained that their form was incompatible with those of the arseniates and green carbonate of copper, with which their external characters bear some resemblance, and I am led, therefore, to consider them as belonging to a new mineral species, to which Mr. Heuland proposes to give the name of *Brochantite*, in honour of a mineralogist as well known here as in his own country.

The appearance of the crystals is that of thin rectangular tables, bevelled on the edges with the angles truncated, such as is represented by fig. 7 (Pl. XXXII). Their colours are emerald green, they are transparent, and their hardness is about the same as that of green carbonate of copper. The planes M are blackish and dull; all the others are brilliant and fit for measurement by the reflective goniometer. I have not been able on the very minute crystals I have examined to ascertain the directions of the planes of cleavage, and I have, therefore, assumed as the primitive a right rhombic prism, fig. 6, the lateral planes of which correspond, I believe, with the planes marked M, fig. 7. The planes e^1 and a^1 are then the results, the first of a decrement by four rows on the angles e of the base of the primitive; the other of a decrement by one row on the angle a. The angles I have

measured are the incidences of e^4 and a^1 on the base, and it is from these data, and from the supposition that 4 and 1 are the indices of these planes, that the angles and dimensions of the primitive are deduced. I have thus found that the lateral planes of the primitive were inclined to each other at an angle of 114° 20′, and that the height was to one side of the base nearly in the ratio of 25 to 12. The other angles are $(a', p) = 104° 75'$, $(e^4 p) = 148° 30'$.

It may appear strange that in the want of sufficient data to determine the primitive form, and being obliged to make a supposition upon the laws of decrements which produce the faces e^4 and a^1, I have not chosen the simpler hypothesis of each of these faces being the result of a decrement by one row. In that case the lateral planes of the primitive would have been inclined at an angle of 162° 18′, and had I supposed 2 instead of 4 for the index of the face e^4, the incidence of the lateral planes would have been 145° 25′. Now though I could not measure the angle of the planes M, fig. 7, their incidence appeared to me much nearer to the angle 114° 20′, which I have chosen, than any of the other two very obtuse angles; this circumstance added to some indications of cleavage in the direction of the same planes, determined me to adopt the number 4.

The crystals are placed upon mamillated green carbonate of copper lying upon massive red copper.

Upon a specimen of wavellite, from Cornwall, belonging to the same collection, I have observed some minute white transparent crystals in the form of acute rhombic octahedrons, with their summits replaced by a plane, see fig. 8. This form is not incompatible with wavellite, whose primitive form is a right rhombic prism. However, in trying to split some of the crystals, I could not perceive any indication of the cleavages which exist in wavellite. The only means to ascertain whether their form could be derived from that of wavellite was in the following manner. First, it is obvious that, in that case, one of the parallelograms ABCD, ABCE, BEDF, must be parallel to the base of the primitive of wavellite. Secondly, one of them must be similar to that base, or at least must be such that when placed in the plane of that base so that its diagonals be parallel to the diagonals of the base, the sides must be found parallel to lines drawn from one of the angles of the base to some simple multiple or part of the opposite sides. If none of these conditions be satisfied, then it may be safely inferred that the two forms are incompatible. But the application of this method supposes that the incidences of the faces of the crystals can be measured with great accuracy, and here the planes were not sufficiently brilliant to answer in the measurements of less than half a degree. Dr. Wollaston kindly undertook an examination of this substance, and the results of his observations were as

follow. His experiments were performed upon two or three small crystals, the largest of which weighed about 1-80th part of a grain. The only substances he could detect in them are alumina and fluoric acid. He also measured the refractive power comparatively with that of wavellite, and found the index of refraction to be 1·47, whilst that of wavellite is 1·52. He is, therefore, of opinion that these crystals belong to a distinct species, for which he proposes the name of *Fluellite*. He also measured the crystals, and found

$$(b, b') = 144° \quad (b, b'') = 109° \quad (b, b) = 82.$$

Hence the primitive form may be assumed to be a right rhombic prism, the lateral planes of which are inclined to each other at about 105°.

I shall conclude this short paper by mentioning, that upon a specimen from Mendip, near Churchill, Somersetshire, I have found a white laminary substance which cleaves with great facility, and brilliant surfaces parallel to the lateral planes and shorter diagonal of a rhombic prism of 102° 25′, and thus differs from sulphate of lead to which it bears a great resemblance, and is very likely the substance, from the same locality analyzed by Berzelius, a notice of which was inserted in the number of the *Annals of Philosophy* for August last. I could find no cleavage in the direction of the base.



Examination of the preceding Mineral by the Blowpipe, &c.

At Mr. Lévy's request, I have examined the *Brochantite* by the blowpipe, but the quantity which he could supply me with was so very small, not exceeding two-tenths of a grain in all, that I have been unable to obtain satisfactory information as to the true composition of the mineral. The results, however, such as they are, I lay before our readers.

A minute crystal, not half the size of the smallest pin's head, heated alone on charcoal, immediately lost its fine green colour, and became dark brown, slightly inclining to a reddish hue, but did not fuse. The heated particle was not attracted by the magnet. Another particle cemented to the end of a fine platina wire by alumina, in the manner recommended by Mr. Smithson, fused readily, and alloyed with the platina.

With soda on the platina wire, and in the *oxidating flame*, the assay gave a brown opaque globule, which was not perceptibly altered in the *reducing flame*.

With borax, in the oxidating flame, the assay gave a transparent, very deep green glass. When the flux was not in large proportion to the assay, the globule appeared black, from the intensity of the colour. In the interior flame the green colour

quickly disappeared, and the globule became red from reduced copper.

With salt of phosphorus, the same as with borax, except that the green colour was not so intense.

The quantity being so minute, I could not expect to detect the presence of arsenic by its odour. I, therefore, sought for arsenic acid by treating a few minute fragments of the crystals on a slip of glass, with potash and nitric acid, &c. but no indication of its presence was afforded by nitrate of silver. With nitrate of lead, the solution gave a considerable precipitate, insoluble, when largely diluted, in excess of nitric acid.

The crystals dissolved completely in muriatic acid without the slightest effervescence, and the solution, diluted with a large quantity of water, gave a white precipitate with muriate of barytes, apparently perfectly insoluble in excess of acid. To ascertain, however, if phosphoric acid be present, I digested the precipitate by muriate of barytes in diluted muriatic acid with heat, decanted the clear fluid, and added ammonia, but not the least cloudiness, indicative of a phosphate, ensued. To be still more certain, I tried the converse of Dr. Wollaston's beautiful and delicate process for detecting the minutest portion of magnesia; that is, I dissolved a portion of the crystals in nitric acid, and to the clear solution added a solution of nitrate of magnesia, and to the mixture an excess of bicarbonate of ammonia. Letters were then described with a glass rod in the solution on the slip of glass, and the mixture slightly warmed over the lamp, but no traces whatever were discernible on the glass. A comparative experiment made with a similar particle of phosphate of copper gave distinct and strong lines on the first impression of the heat.

As from the experiment with muriate of barytes, a sulphate appears to be present, a portion of the crystals was heated in pure water, and the liquid tested with muriate of barytes, but no precipitate ensued; the water did not appear to have dissolved any thing; the appearance of the crystals was wholly unaltered. I could not detect any trace of lime, magnesia, manganese, or iron, in the crystals, nor any decisive indications of alumina or silica; in short, nothing but copper and sulphuric acid; and yet they appear to be wholly insoluble in water. A particle of a crystal laid in a drop of water on a clean polished bar of iron, and the water evaporated to dryness left no trace of copper, nor any more mark than another drop of the same water evaporated to dryness beside it.

Prussiate of potash indicated nothing in the solutions but copper.

From the insolubility of the crystals in pure water, and their fine green colour, it can hardly be doubted that they must contain something else besides sulphuric acid and oxide of copper;

but what the ingredients may be that have escaped detection, I must leave to future experiments, if hereafter I may obtain a larger supply of the crystals, to determine. J. G. C.

P. S. From some very indecisive appearances that occurred in the examination of the globule with salt of phosphorus, I am inclined to think that alumina or silica, or both, may be constituent parts of the crystals; but I have no means of confirming or disproving the conjecture.

Article II.

On the Heat produced by firing Gunpowder, and on the intense Heat of Blast-furnaces. By W. T. Haycraft, Esq.*

The following explanations on these subjects are suggested by Mr. Haycraft, towards the conclusion of his paper on the "Specific Heat of Gases."

The increased capacity of air, when under lesser degrees of atmospheric pressure, has been properly made use of to explain the extreme cold which exists in high regions; and its decreased capacity under mechanical pressure also satisfactorily accounts for the heat evolved under that condition. This principle, so far as I know, has not been used to explain one cause of the intense heat produced during the combustion of gunpowder and other explosive mixtures. If we reflect a moment, however, we shall perceive that the resistance of the pressure of the atmosphere to the expansion of the nascent gases produced by the combustion, will cause them to exist in a state of greater density than when the resistance of the atmosphere has been finally overcome. It is during this state of potential compression, if I may use the term, that the intense heat is produced. After the first explosion, however, the gaseous products will expand, and then there will necessarily be absorption of caloric, and consequently comparative coldness produced. In order to ascertain whether there is a permanent evolution of caloric, occasioned by the combustion of gunpowder, I made the following experiment.

Having a receiver containing 528 cubic inches, filled with water of a temperature of 52°, placed in a pneumatic trough, the surrounding atmosphere being also 52°, I introduced 240 inches of the aeriform fluids, produced during the combustion of that composition of gunpowder which is used for pyrotechnical purposes. After the explosion, the gas in the upper part of the receiver had acquired a temperature of nearly 54°, and the water not so much. This experiment shows that though heat is

* From the Transactions of the Royal Society of Edinburgh.

evolved in the combustion of gunpowder, its quantity is not nearly so great as has been imagined. Again, if we consider that the products of the combustion of gunpowder have not, by direct experiment, been proved to have a greater specific heat than the ingredients of that composition, the phenomenon of heat being produced during that combustion should not be urged as an objection to the hypothesis of Black and Crawford. Indeed, it appears very probable, from the inspection of the Table of Specific Heats of Different Bodies, that those elastic products have a less capacity than the ingredients of gunpowder from which they are produced. For example, azote, which composes two-thirds of the elastic products, has a capacity of 2669, and carbonic acid, comprising one-third of the products, if my experiments are to be trusted to, has a capacity of only 1751, water being 10000. Nitric acid, of a specific gravity of 1354, has a capacity of 5760. The azote, therefore, and oxygen, which is produced from the decomposition of one of the ingredients forming the elastic products of not half the specific heat of that ingredient, should, according to the hypothesis of Black, evolve heat. This might take place even if we make allowance for the lesser capacity which nitric acid has in its state of one of the ingredients of the nitrate of potash.

The same condition of potential compression may also contribute to the intense heat which takes place in a blast-furnace. This heat is known by all conversant with the phenomenon to be, not in a ratio of the fuel consumed, but of some compound ratio. This may be explained in the following manner: 1. A quantity of air is forced into contact with the coals in a state of ignition, and its temperature is suddenly raised extremely high. 2. In this condition, were it not for the pressure of the atmosphere, it would become as suddenly expanded. 3. Had this expansion taken place, it would have acquired an increased capacity, and would consequently have absorbed a considerable portion of the caloric evolved by the combustion, tending thereby to lessen the capacity of the heat. 4. But the heated air being prevented by the pressure of the atmosphere from expanding in a ratio equal to the temperature acquired, the absorption of caloric is lessened, and a greater proportion of the heat of combustion is rendered free. Thus, although the total quantity of caloric evolved at, and consequently to combustion, may be in a direct ratio of the quantity of fuel consumed; yet the intensity of the thermometrical heat at the moment, and at the place of combustion, will be greater in a compound ratio, directly as the pressure of the atmosphere, and inversely as the times of expansion of the air employed in the blast. These times are, of course, inversely as the intensity of the blast. The thermometrical heat then, at the moment and place of combustion, will be in a compound ratio of the quantities of fuel consumed, the weight of the atmosphere,

and the quantity of air employed in the blast in a given time. The same rule will hold even in what are called chimney furnaces; and it is ascertained by experience, that those furnaces of steam-engines through which a greater quantity of air passes in a given time, consume a proportionally less quantity of fuel to produce the same effect. Probably blast-furnaces might be advantageously employed in lessening the quantity of fuel used for those valuable machines.

Although, according to the foregoing experiment, it appears contrary to my original expectation, that, by volume, oxygen gas has the same specific heat as carbonic acid, it by no means follows that caloric should not be evolved during the formation of the latter by combustion. This formation does not consist of a conversion of oxygen into carbonic acid, but of a union of two ingredients into a compound, having an absolute capacity for caloric equal to one of the ingredients only, namely, the oxygen gas; consequently the whole absolute heat of the carbon is rendered free.

Article III.

On Subphosphuretted Hydrogen Gas. By Dr. Thomson, FRS.

(To the Editors of the *Annals of Philosophy*.)

GENTLEMEN, *Glasgow, Sept.* 9, 1824.

In the account of subphosphuretted hydrogen gas, inserted in the last number of the *Annals*, I observe a mistake into which I had fallen while hastily transcribing the account from my common-place book. I have misstated the specific gravity of hydrogen gas. The statement in page 205 of the last number should have been as follows:

"Subphosphuretted hydrogen gas is composed of

1 volume hydrogen gas	0·0694
0·75 volume phosphorus vapour.	0·6250
	0·6944

So that its specific gravity is reduced from 0·9027 to 0·6944, and it contains just nine times as much phosphorus as hydrogen. It may be reckoned a compound of 4 atoms hydrogen and 3 atoms phosphorus."

Your noticing this error in your next number will much oblige,

Gentlemen, yours truly,

Thomas Thomson.

Article IV.

Corrections in Right Ascension of 37 *Stars of the Greenwich Catalogue.* By James South, FRS.

Mean AR 1824.	γ Pegasi h. m. s. 0 4 11·17	Polaris h. m. s. 0 58 2·66	α Arietis h. m. s. 1 57 16·42	α Ceti h. m. s. 2 53 5·44	Aldebaran h. m. s. 4 25 50·01	Capella h. m. s. 5 3 42·21	Rigel h. m. s. 5 6 5·11	β Tauri h. m. s. 5 15 10·52	α Orionis h. m. s. 5 45 38·93
Oct. 1	+ 4·62″	+ 56·99″	+ 4·90″	+ 4·43″	+ 4·45″	+ 5·54″	+ 3·64″	+ 4·64″	+ 3·83″
2	62	57·16	92	45	48	58	67	67	86
3	63	57·27	93	47	50	62	69	70	89
4	63	57·38	95	49	53	66	72	73	92
5	63	57·48	96	51	56	70	75	77	95
6	64	57·59	98	53	58	74	77	80	98
7	64	57·70	99	55	61	78	80	83	4·01
8	64	57·74	5·00	57	64	81	83	86	04
9	64	57·78	02	59	66	85	85	89	07
10	64	57·82	03	60	69	88	88	92	09
11	64	57·86	04	62	71	92	90	95	12
12	64	57·90	05	63	74	95	93	98	15
13	64	57·88	06	65	76	98	95	5·02	18
14	63	57·85	08	66	79	6·02	98	05	20
15	63	57·83	09	68	82	05	4·00	08	23
16	63	57·80	10	69	85	09	03	11	26
17	63	57·78	12	71	87	12	06	14	29
18	63	57·71	13	72	89	16	08	17	32
19	63	57·64	13	74	91	20	11	20	34
20	63	57·57	14	75	94	24	13	23	37
21	62	57·50	15	77	96	28	16	26	40
22	62	57·43	16	78	98	32	18	29	43
23	62	57·25	17	79	5·01	36	20	32	45
24	62	57·08	17	81	03	40	23	36	48
25	61	56·90	18	82	05	44	25	39	50
26	61	56·73	18	83	08	48	27	42	53
27	61	56·55	19	85	10	52	30	45	56
28	61	56·34	20	86	12	55	32	48	59
29	60	56·13	20	87	14	58	34	50	61
30	59	55·92	21	88	16	61	37	53	63
31	59	55·71	22	89	18	65	39	56	66
Nov. 1	58	55·50	22	90	20	68	41	59	68
2	58	55·22	23	91	22	71	43	61	71
3	57	54·94	24	92	24	74	45	64	73
4	57	54·67	25	93	26	78	48	66	76
5	56	54·39	25	94	28	81	50	69	79
6	56	54·11	26	95	30	84	52	72	82
7	55	53·79	26	96	32	87	54	74	84
8	54	53·46	27	97	34	90	56	77	87
9	54	53·14	27	98	35	93	58	79	89
10	53	52·81	28	99	37	96	60	81	92
11	52	52·49	28	5·00	39	99	62	84	94
12	51	52·10	28	01	41	7·01	65	86	97
13	50	51·71	28	01	42	04	67	89	99
14	50	51·32	29	02	44	07	69	91	5·02
15	49	50·93	29	03	46	10	71	94	04
16	48	50·54	30	04	48	13	73	96	07
17	47	50·11	30	04	50	15	75	98	09
18	46	49·68	30	05	51	18	76	6·00	11
19	45	49·24	30	05	53	20	78	02	13
20	44	48·81	30	06	54	23	80	04	15
21	43	48·38	30	06	56	25	81	06	17
22	42	47·89	30	07	57	28	83	08	20
23	42	47·40	30	07	59	30	85	11	22
24	41	46·92	30	08	60	33	87	13	24
25	40	46·43	30	08	62	35	88	15	26
26	39	45·94	30	09	61	38	90	17	28
27	38	45·41	30	09	65	40	91	19	30
28	37	44·88	29	09	66	41	92	20	31
29	36	44·36	29	09	67	43	93	22	33
30	35	43·83	28	09	68	45	95	23	35

	Sirius	Castor	Procyon	Pollux	α Hydræ	Regulus	β Leonis	β Virginis	SpicaVirg.
Mean AR 1824.	h. m. s. 6 37 23·49	h. m. s. 7 28 21·46	h. m. s. 7 30 5 32	h. m. s. 7 34 32·18	h. m. s. 9 18 56 44	h. m. s. 9 58 59 57	h. m. s. 11 40 4·73	h. m. s. 11 41 31·86	h. m. s. 13 15 56 07
Oct. 1	+ 2·92″	+ 3·95″	+ 3·19″	+ 3·74″	+ 2·44″	+ 2·59″	+ 2·17″	+ 2·25″	+ 2·21″
2	95	99	22	77	46	61	18	27	21
3	98	4·02	25	81	49	63	19	28	21
4	3·01	06	28	84	51	65	20	29	21
5	04	09	30	87	53	67	22	30	22
6	07	13	33	91	56	69	23	31	22
7	10	16	36	94	58	71	24	32	22
8	13	20	39	97	61	74	26	34	23
9	15	23	42	4·01	63	76	27	35	24
10	17	27	45	04	66	79	29	37	24
11	20	30	48	07	68	81	30	38	25
12	23	34	51	10	71	84	32	40	26
13	26	37	54	14	73	86	34	42	27
14	29	41	57	17	76	89	35	43	28
15	31	45	60	20	78	91	37	45	28
16	34	48	63	24	81	94	38	46	29
17	37	52	66	27	83	96	40	48	30
18	40	56	69	31	86	99	42	50	31
19	43	59	72	34	89	3·01	44	52	32
20	46	63	75	38	91	04	46	54	33
21	49	66	78	41	94	07	48	56	34
22	52	70	81	45	97	10	50	58	35
23	55	74	84	48	3·00	12	51	60	36
24	58	77	87	52	02	15	53	61	37
25	61	81	90	55	05	18	55	63	38
26	64	84	93	59	08	20	57	65	39
27	67	88	96	62	11	23	59	67	41
28	70	91	99	65	14	26	61	69	42
29	72	95	4·02	69	17	29	64	72	44
30	75	98	05	72	20	32	66	74	45
31	78	5·02	08	75	23	35	68	76	47
Nov. 1	81	05	10	79	26	38	71	78	48
2	83	09	13	82	29	41	73	81	50
3	86	12	16	86	32	44	76	83	51
4	89	16	19	89	35	47	78	85	53
5	91	19	22	92	38	50	81	88	54
6	94	23	25	96	41	53	83	90	56
7	97	27	28	99	44	56	86	93	58
8	99	30	31	5·03	47	59	88	95	60
9	4·02	34	34	06	50	62	91	98	62
10	05	37	37	10	53	65	94	3·01	64
11	08	41	40	13	56	69	97	02	66
12	11	44	43	16	59	72	99	04	68
13	13	48	46	20	63	75	3·02	09	70
14	16	51	49	23	66	78	04	12	72
15	18	55	52	27	69	81	07	14	74
16	21	58	55	30	72	84	10	17	76
17	23	61	58	33	75	87	13	20	78
18	26	65	61	36	78	91	16	23	81
19	28	68	64	40	82	94	19	26	83
20	31	71	67	43	85	97	22	29	85
21	33	74	70	46	88	4·01	24	32	88
22	35	78	73	49	91	04	27	35	90
23	38	81	76	52	94	08	30	38	93
24	40	85	79	56	97	11	33	41	95
25	43	88	82	59	4·01	15	36	44	98
26	45	91	85	62	04	18	39	47	3·00
27	47	94	87	65	07	21	42	50	03
28	49	97	90	68	10	24	45	53	06
29	51	6·00	92	71	13	27	48	56	08
30	53	03	95	74	16	31	51	59	11

Mean AR 1824.	Arcturus h. m. s. 14 7 38·33	2α* Libræ h. m. s. 14 41 9·63	α Cor. Bor h. m. s. 15 27 14·45	ι Serpent. h. m. s. 15 35 36·47	Antares h. m. s. 16 18 27·91	α Herculis h. m. s. 17 6 37·72	α Ophiuchi h. m. s. 17 26 46·24	α Lyræ h. m. s. 18 30 58·99	γ Aquilæ h. m. s. 19 37 53·68
Oct. 1	+ 1·85″	+ 2·55″	+ 1·80″	+ 2·38″	+ 3·35″	+ 2·53″	+ 2·68″	+ 2·19″	+ 3·46″
2	84	54	79	37	34	51	66	17	44
3	84	53	77	36	32	50	64	14	42
4	83	53	76	35	31	48	63	12	41
5	83	52	75	33	30	46	61	09	39
6	83	52	73	32	28	45	60	07	37
7	82	51	72	31	27	43	58	04	36
8	82	51	71	30	26	42	56	02	34
9	82	50	70	30	25	40	55	1·99	33
10	82	50	69	29	24	39	53	97	31
11	82	50	68	28	23	37	52	95	30
12	82	50	67	27	21	36	50	92	28
13	82	49	66	27	20	34	49	90	26
14	82	49	65	26	19	33	47	87	25
15	82	49	64	25	18	31	46	85	23
16	82	48	63	25	17	30	44	82	22
17	82	48	62	24	16	28	42	80	20
18	82	48	61	24	15	27	41	78	18
19	83	48	61	23	15	26	40	75	16
20	83	48	60	23	14	25	39	73	15
21	84	48	60	22	14	23	37	71	13
22	84	48	59	22	13	22	36	69	11
23	84	48	59	22	13	21	35	66	09
24	85	50	58	21	12	20	34	64	07
25	85	50	58	21	12	18	32	62	05
26	86	50	58	21	11	17	31	59	04
27	86	50	57	20	10	16	30	57	02
28	87	51	57	20	10	15	29	55	01
29	88	52	57	20	10	14	28	53	2·99
30	88	52	57	20	10	14	27	51	98
31	89	53	57	20	09	13	26	49	96
Nov. 1	90	54	57	20	09	12	25	48	95
2	91	55	57	20	09	11	24	46	93
3	91	56	57	20	09	10	23	44	92
4	92	57	57	20	09	10	22	42	90
5	93	58	57	20	08	09	21	40	89
6	94	59	57	20	08	08	20	38	87
7	95	60	58	21	08	08	20	36	86
8	97	61	58	21	08	07	19	35	85
9	98	63	59	22	09	07	19	33	84
10	99	64	59	22	09	07	19	32	82
11	2·01	65	60	23	09	07	18	30	81
12	02	67	60	23	09	06	18	28	80
13	04	68	61	24	10	06	18	26	79
14	05	69	61	24	10	06	17	24	78
15	07	70	61	25	10	06	17	23	76
16	08	72	62	26	11	05	16	21	75
17	10	74	63	27	12	05	16	20	74
18	12	75	64	28	13	05	16	19	73
19	14	77	65	29	13	05	16	17	72
20	16	79	66	31	14	05	16	16	71
21	18	81	67	32	15	05	16	15	70
22	20	82	68	33	16	05	16	14	69
23	22	84	69	34	17	06	16	13	68
24	24	86	70	35	17	06	16	12	67
25	26	87	71	36	18	06	16	11	66
26	28	89	73	38	19	06	16	10	66
27	30	91	74	39	20	06	16	09	65
28	32	93	76	41	22	07	17	08	65
29	34	95	77	42	23	07	17	08	64
30	37	97	79	43	25	08	17	07	63

* Mean AR of 1 α Libræ, $14^h\ 40'\ 58{\cdot}21''$.

	α Aquilæ	β Aquilæ	♑ α* Capri.	α Cygni	α Aquarii	Fomalhaut	α Pegasi	γ Androm.
Mean AR 1824.	h. m. s. 19 42 11·88	h. m. s. 19 46 40·23	h. m. s. 20 8 17·02	h. m. s. 20 35 26·21	h. m. s. 21 56 44·67	h. m. s. 22 47 54·34	h. m. s. 22 56 0·17	h. m. s. 23 59 18·67
Oct. 1	+ 3·55″	+ 3·61″	+ 4·17″	+ 3·06″	+ 4·32″	+ 4·95″	+ 4·40″	+ 4·72″
2	53	59	15	03	31	95	39	72
3	51	58	14	01	30	94	39	72
4	49	56	12	2·98	29	94	38	72
5	48	55	11	96	29	93	38	73
6	46	53	09	93	28	93	37	73
7	45	51	08	91	27	92	37	73
8	43	49	07	89	26	91	36	73
9	42	48	05	86	25	91	36	73
10	40	46	04	84	·24	90	35	73
11	39	45	02	82	24	89	35	73
12	37	43	01	79	23	88	34	73
13	35	42	3·99	78	22	87	33	73
14	34	40	98	76	21	86	33	72
15	32	39	96	73	20	86	32	72
16	31	37	95	70	19	85	32	72
17	29	35	93	67	18	84	31	72
18	27	33	91	65	17	83	30	72
19	26	32	90	62	15	82	29	71
20	24	30	88	60	14	80	28	71
21	22	29	87	57	13	79	27	70
22	20	27	85	54	12	78	26	70
23	19	25	84	52	10	77	25	69
24	17	24	82	49	09	76	24	69
25	15	22	80	46	08	75	23	68
26	14	21	78	44	06	73	22	68
27	12	19	77	41	05	72	21	67
28	11	17	76	39	04	71	20	66
29	09	16	74	36	02	70	19	66
30	08	14	73	34	01	69	18	65
31	07	13	72	31	00	67	17	64
Nov 1	05	11	70	29	3·99	66	16	63
2	04	10	69	26	98	65	16	63
3	02	08	67	24	96	64	15	62
4	01	07	66	21	95	62	14	61
5	2·99	05	64	19	93	61	13	61
6	98	04	63	16	92	60	12	60
7	97	03	62	14	91	59	11	59
8	95	01	60	11	90	57	10	58
9	94	00	59	09	88	56	08	58
10	93	2·99	58	07	87	55	07	57
11	92	98	57	05	86	53	06	56
12	90	96	55	03	85	52	05	55
13	89	95	54	01	84	50	04	54
14	88	94	53	1·99	82	49	02	54
15	86	92	51	96	81	47	01	53
16	85	91	50	93	80	46	00	52
17	84	90	49	91	79	45	3·99	51
18	83	89	48	89	78	43	98	50
19	82	89	47	86	76	42	96	49
20	82	88	46	84	75	41	95	48
21	81	87	45	82	74	39	94	47
22	80	86	45	80	73	38	93	46
23	80	85	44	78	72	36	92	45
24	79	85	43	75	70	35	90	43
25	78	84	42	73	69	33	89	42
26	77	83	41	71	68	32	88	41
27	76	82	40	69	67	30	87	40
28	75	81	39	67	66	29	85	38
29	75	81	38	65	65	27	84	37
30	74	80	37	63	63	26	83	36

* Mean AR of 1 α Capricor. 20^h 7′ 53·23″.

Mean AR 1824.	γ Pegasi h. m. s. 0 4 11·17	Polaris h. m. s. 0 58 2·66	α Arietis h. m. s. 1 57 16·42	α Ceti h. m. s. 2 53 5·44	Aldebaran h. m. s. 4 25 50·01	Capella h. m. s. 5 3 42·21	Rigel h. m. s. 5 6 5·1	β Tauri h. m. s. 5 15 10·52	α Orionis h. m. s. 5 45 38·93
Dec. 1	+ 4·33″	+43·30″	+ 5·28″	+ 5·09″	+ 5·69″	+ 7·46″	+ 4·96″	+ 6·25″	+ 5·36″
2	32	42·72	27	09	70	48	97	26	38
3	31	42·14	27	09	71	50	98	28	40
4	30	41·56	26	09	72	51	5·00	30	41
5	29	40·98	26	10	73	53	01	32	43
6	28	40·40	25	10	74	55	02	33	45
7	27	39·80	25	10	75	57	03	34	46
8	26	39·20	24	10	75	58	04	36	48
9	25	38·60	24	10	76	60	05	37	49
10	24	38·01	23	09	77	61	06	39	51
11	23	37·41	23	09	77	63	07	40	52
12	22	36·75	22	09	78	64	08	42	54
13	20	36·09	22	09	79	66	09	43	55
14	19	35·43	21	09	80	67	09	44	57
15	18	34·76	21	08	80	69	10	46	58
16	17	34·10	20	08	81	70	11	47	59
17	16	33·45	19	08	81	71	12	48	60
18	15	32·80	18	07	81	72	12	49	61
19	14	32·15	17	07	82	73	13	49	62
20	13	31·49	16	06	82	74	14	50	63
21	12	30·84	15	06	82	74	15	51	64
22	11	30·15	15	05	83	75	15	52	65
23	10	29·46	14	05	83	76	16	53	66
24	09	28·77	13	04	83	77	16	53	67
25	08	28·08	12	04	84	78	17	54	68
26	07	27·38	11	03	84	79	17	55	69
27	06	26·69	10	03	84	80	17	56	70
28	05	26·00	09	02	84	81	17	56	71
29	04	25·31	09	02	84	82	17	57	71
30	02	24·62	08	01	84	83	18	57	72
31	01	23·93	07	00	84	84	18	58	73

Mean AR 1824.	Sirius h. m. s. 6 37 23·49	Castor h. m. s. 7 23 21·46	Procyon h. m. s. 7 30 5·32	Pollux h. m. s. 7 34 32·18	α Hydræ h. m. s. 9 18 56·44	Regulus h. m. s. 9 58 59·57	β Leonis h. m. s. 11 40 4·73	β Virginis h. m. s. 11 41 31·86	SpicaVirg. h. m. s. 13 15 56·07
Dec. 1	+ 4·55	+ 6·06″	+ 4·97″	+ 5·77″	+ 4·19″	+ 4·34″	+ 3·54″	+ 3·63″	+ 3·14″
2	58	09	5·00	80	22	37	57	66	17
3	60	12	02	83	25	40	60	69	20
4	62	15	05	86	28	44	63	72	23
5	64	18	07	89	32	47	67	75	25
6	66	21	10	92	35	50	70	78	28
7	68	24	12	95	38	53	73	81	31
8	70	26	15	97	41	56	77	85	34
9	71	29	17	6·00	44	60	80	88	37
10	73	31	19	03	47	63	83	91	40
11	75	34	21	06	50	66	87	94	43
12	77	36	24	08	53	69	90	97	46
13	78	39	26	11	55	72	94	4·00	49
14	80	42	28	14	58	76	97	03	52
15	82	45	31	16	61	79	4·01	07	55
16	84	47	33	19	64	82	04	11	58
17	85	49	35	21	67	85	07	14	61
18	87	51	37	23	69	88	11	17	64
19	88	54	39	26	72	91	14	21	67
20	89	56	41	28	75	94	17	24	70
21	90	58	43	30	78	97	20	27	73
22	92	60	44	32	80	5·00	24	30	76
23	93	62	46	34	83	03	27	33	79
24	94	64	48	37	86	06	30	37	82
25	96	67	50	39	88	09	34	40	86
26	97	69	52	41	91	12	37	43	89
27	98	71	54	43	93	15	40	46	92
28	99	73	56	45	96	18	43	49	95
29	5·00	75	58	47	98	21	46	53	98
30	02	77	59	49	5·01	24	50	56	4·02
31	03	79	61	51	04	27	53	59	06

Mean AR 1824.	Arcturus h. m. s. 14 7 38·33	2 α Libræ h. m. s. 14 41 9·63	α Cor. Bor. h. m. s. 15 27 14·45	α Serpent. h. m. s. 15 35 36·47	Antares h. m. s. 16 18 27·91	α Herculis h. m. s. 17 6 37·72	α Ophiuchi h. m. s. 17 26 46·24	α Lyræ h. m. s. 18 30 58·99	γ Aquilæ h. m. s. 19 37 53·63
Dec. 1	+ 2·39″	+ 2·99″	+ 1·80″	+ 2·45″	+ 3·26″	+ 2·08″	+ 2·17″	+ 1·06″	+ 2·63′
2	41	3·01	82	46	27	09	17	05	62
3	43	04	83	48	29	09	18	04	61
4	45	06	85	49	30	10	18	04	61
5	48	08	86	50	31	10	19	03	60
6	50	10	88	52	33	11	19	02	59
7	53	13	90	54	35	12	20	02	59
8	55	15	92	56	37	13	21	02	59
9	58	18	94	58	39	14	21	02	58
10	61	20	96	60	41	15	22	02	58
11	64	23	98	62	43	16	23	01	58
12	66	25	2·00	64	45	17	24	01	57
13	69	28	02	66	46	18	24	01	57
14	72	30	04	68	48	19	25	01	57
15	74	33	06	70	50	20	26	00	57
16	77	36	08	72	52	22	27	00	56
17	80	39	10	74	54	23	28	00	56
18	83	42	13	77	56	25	30	00	56
19	86	45	15	79	58	26	31	00	56
20	89	48	17	81	61	28	32	00	56
21	92	51	20	83	63	29	34	00	56
22	94	53	22	86	65	31	35	01	56
23	97	56	25	88	67	32	37	01	57
24	3·00	59	27	90	70	34	38	01	57
25	03	62	30	93	72	35	40	01	57
26	06	65	32	95	74	37	41	01	57
27	09	68	35	98	77	39	43	02	58
28	12	71	38	3·00	79	41	44	02	58
29	15	74	40	03	82	42	46	02	58
30	19	77	43	05	84	44	48	03	59
31	22	80	46	08	87	46	50	03	59

Mean AR 1824.	α Aquilæ h. m. s. 19 42 11·88	β Aquilæ h. m. s. 19 46 40·23	2 α Capricer h. m. s. 20 8 17·02	α Cygni h. m. s. 20 35 26·21	α Aquarii h. m. s. 21 56 44·67	Fomalhaut h. m. s. 22 47 54·31	α Pegasi h. m. s. 22 56 0·17	α Androm. h. m. s. 23 59 18·67
Dec. 1	+ 2·73″	+ 2·79″	+ 3·37″	+ 1·61″	+ 3·62″	+ 4·24″	+ 3·81″	+ 4·35″
2	72	78	36	59	61	22	80	34
3	71	77	35	57	60	21	79	32
4	70	76	34	54	58	19	77	31
5	70	76	33	52	57	18	76	30
6	69	75	32	50	56	16	75	28
7	69	75	32	48	55	15	74	27
8	68	74	31	47	54	14	73	26
9	68	74	31	45	53	13	72	25
10	68	74	31	44	52	11	71	23
11	68	73	31	42	51	10	70	22
12	67	73	30	41	51	09	68	21
13	67	73	30	39	50	08	67	20
14	67	73	30	38	49	07	66	19
15	66	72	29	36	48	05	65	17
16	66	72	29	35	47	04	64	16
17	66	72	29	34	46	03	63	15
18	66	72	29	33	45	01	62	13
19	66	72	29	32	45	00	61	12
20	66	72	29	30	44	3·99	60	11
21	66	72	29	29	43	98	59	09
22	66	73	29	28	42	96	58	08
23	67	73	28	27	42	95	57	06
24	67	73	28	26	41	94	56	05
25	67	73	28	24	40	92	54	03
26	67	73	28	23	39	91	53	02
27	67	73	28	22	38	90	52	01
28	68	73	28	21	38	89	51	3·99
29	68	74	28	20	37	88	50	98
30	68	74	29	19	37	87	49	97
31	69	74	29	18	36	86	48	95

Article V.

On the Expansion of Liquids. By the Rev. J. B. Emmett.

(To the Editors of the *Annals of Philosophy*.)

GENTLEMEN, *Great Ouseburn, Aug.* 14, 1824.

If the temperatures be taken in arithmetical progression, the volumes of a liquid at those temperatures are the logarithms of a certain series of numbers in arithmetical progression, which latter are, of course, the reciprocals of a series of numbers in harmonical progression. This estimate is sufficiently accurate for the graduation of thermometers which require the true scale, the approximation being so near the truth, that for mercurial or alcoholic thermometers, the deviation will not be perceptible, except very near the boiling and freezing points. The rigorous law is connected with some mathematical investigations, which have not yet been published, but which will appear as soon as my health will allow me to make some requisite experiments and calculations. The true law is this: if the temperature increase in arithmetical progression, the volumes will increase according to the following law, an increasing geometrical × increasing arithmetical progression. As the common difference of the latter series is very small, it may be neglected, except for changes near to the two points named. This closely coincides with the table of expansions given by Dr. Thomson: the first column is the temperature; the second, the volume of the liquid from the above tables; the third, the numbers to which column 2 are logarithms; the fourth, the differences of the successive numbers of column 3.

Mercury.

Temperature.	Volume.	Log. of	Diff. of numbers.
50°	100183	12594·5	
			9·48
80	—508	12603·98	
			8·82
110	—813	12612·8	
			8·9
140	—1119	12621·7	
			8·9
170	—1424	12630·6	
			8·9
200	—1730	12639·5	

Sulphuric Acid.

Temperature.	Volume.	Log. of	Diff. of numbers.
50°	100000	12591·6	
			21·0
80	—806	12612·6	
			21·3
110	—1540	12633·9	
			25·5
140	—2320	12659·4	
			20·6
170	—3116	12680·0	
			23·1
200	—3911	12703·1	

Nitric Acid.

Temperature.	Volume.	Log. of	Diff. of numbers.
50°	100000	12589·2	
			44·4
80	—1530	12633·6	
			48·6
110	—3196	12682·2	
			46·7
140	—5132	12738·9	

Water.

Temperature.	Volume.	Log. of	Diff. of numbers.
50°	100023	12590·0	
			4·9
70	—197	12594·0	
			4·4
90	—694	12669·3	

Alcohol.

Temperature.	Volume.	Log. of	Diff. of numbers.
40°	100539	12604·8	
			33·4
60	—1688	12638·2	
			35·1
80	—2890	12673·3	
			37·1
100	—4162	12710·4	

On account of the great expansion of alcohol, and the lowness of its point of ebullition, the expansion arising from the arithmetical series, which has to be multiplied into the geometric, is very perceptible; in all the others, the inequality of the differences in the fourth column is less than the inevitable errors of observation.

To show the comparative expansions, the volumes of the liquids should not be equal at a given temperature, but should be the volumes of weights which are proportional to the atomic weights; then the above numbers will enable us to determine the relative quantities of caloric contained in the above volumes.

These points will form the subject of a separate communication. I am, &c. J. B. Emmett.

Article VI.

Account of a new Air Pump. In a Letter to the Editor from Mr. Joseph H. Patten.* (With a Plate.)

I inclose for your inspection the draught of a pneumatic pump, which, I think, will, in a considerable measure, obviate the defects of those in common use. The construction is so simple that it will require but a small share of skill or ingenuity to put it together, and it will be less liable to get out of repair than the pumps now in use. The valves which in other machines

* From the American Journal of Science.

are a great source of difficulty, may be made larger and stronger, and the apertures, of course, will be more accurately closed, without at all affecting the degree of exhaustion. The vapour arising from the oil necessarily used in all pneumatic instruments, is in this completely excluded from the receiver, and the vacuum in the *exhauster* being torricellian, that in the receiver will approach as near to it as the elasticity of the air will permit. The glass parts of the instruments can be obtained from any glass house, and the barrel (which would be more elegant of glass) can be made at any steam-engine or gun manufactory, and a clock maker will be competent to construct the brass work. The subjoined sketch, although not drawn by an adept in the art, will, I hope, give you an idea of it. It represents a vertical section of a *table* pump, supposed to be divided directly through the centre, with one half of the wood work, to which it is attached.

It is a number of months since I first thought of it; I then had one constructed with a barrel of *sheet brass*, and the plate of the pump of tinned iron; it was very coarsely done, and the exhauster was filled with *linseed oil*, but notwithstanding its roughness, it far exceeded my expectations. I have never yet been able to get an iron barrel, as it cannot be procured here, and numerous avocations have prevented its being obtained elsewhere.

Figs. 9 and 10 (Pl. XXXII) correspond in their lettering.

In fig. 9, A B, C D, E F, represent a vertical section of the instrument, G is a barrel of cast iron or glass, screwed firmly to the table E F, in it is the solid piston H moved by the rack work I. K is a glass globe resting upon the table C D, of a little less capacity than the barrel G with which it communicates by the glass tubes L and M firmly cemented into the piece N and into the bottom of the barrel G. To the top of the globe K is cemented the thick cap O, through which are made two apertures, into one of which is screwed the stop-cock P communicating with the plate of the pump R; over the other aperture rests the valve S opening into the atmosphere (the construction is seen in fig. 10). In the globe K is a stiff wire ascending into the cock P a short distance, and on it is screwed the valve T; the other end descends into the tube L, and to it is attached the wooden or cork ball U. We will now suppose the piston H withdrawn, and the barrel G filled with quicksilver; the tubes L and M being open will be filled to the height of the dotted line. Put the piston carefully in so that no air shall be between it and the mercury. As the piston descends, the mercury rises, and when it reaches the ball U it floats it, and by means of the wire forces the valve T against the aperture that communicates with the receiver R, and as the mercury continues to rise, the air driven before it has no way of escaping but through the

Fig. 9.

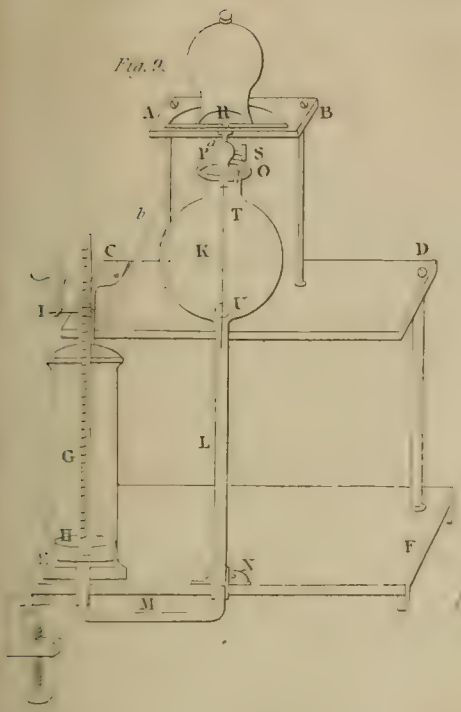


Fig 10

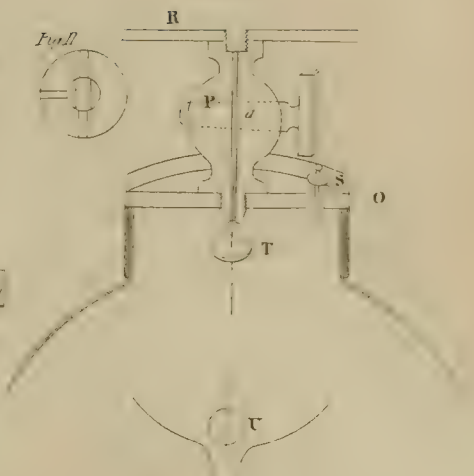


Fig. 11

Fig. 7.

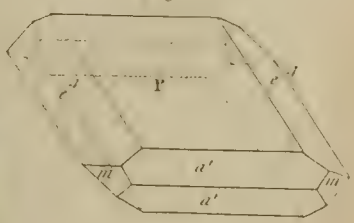


Fig 6



Fig 12.



Fig 8

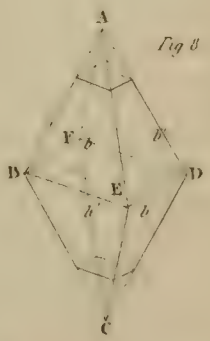


Fig 1

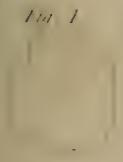


Fig 2



Fig 3

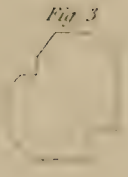


Fig 4

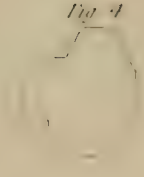
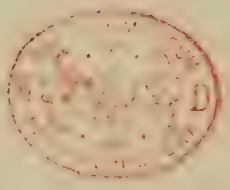


Fig 5





valve S. The piston is now at the bottom of the barrel, and the globe is full of mercury,—if the piston be now drawn up, a vacuum would be formed in the *barrel*, but the mercury in the globe *must* descend as it is above the level of the piston the whole height T, and the vacuum in the globe K would be Torricellian were there not a communication between it and the receiver R. When the mercury again ascends into the globe, it expels every particle of air provided the mercury rises into the aperture at S; and to ensure this the cap O is formed into a rim so as always to supply the contraction or waste, and it is admitted towards the end of the exhaustion by raising the valve S with the finger. The air is admitted through a hole *a* in the cock P, a section is shown, fig. 11. The cap O should be strong, and, if brass, should be coated with the cement used in attaching it to the glass (that used for nautical machines is best), the gauge may be attached to the cap, or inclosed in the receiver.

The stiff wire, with the valve T and the ball U, may be entirely removed; and for it may be substituted a glass tube open at both ends cemented into the cock P, and reaching almost to the bottom of the globe. The mercury, when it rises to the lower end of this tube, cuts off the communication with the receiver. This will perhaps be the simplest and best plan. It may be made a double pump by connecting the cap O with the barrel G, as on the dotted line *b*—one valve opening in and one out. The weight of the mercury will be no objection as the machine is small—the diameter of the globe about four inches, the height of the barrel about eight, and the whole height to the plate R, 15 or 20 inches.

Article VII.

Reply to the Remarks of X. on certain Subjects in Mr. Daniell's Meteorological Essays. By J. F. Daniell, Esq.

(To the Editors of the *Annals of Philosophy*.)

GENTLEMEN, *Gower-street, Sept.* 4, 1824.

Your correspondent X. has committed a great mistake in his remarks upon my work, which, as having found its way into the *Annals of Philosophy*, it may not be unnecessary to correct.

He observes, "It has always been understood that, other circumstances being alike, mercury in the barometer will have its altitude affected by the existing temperature *in no other way than as that temperature alters its specific gravity*." It is scarcely worth while, perhaps, to remark the inaccuracy of this expression, but the fact is, the altitude of the mercury in the barometer,

in measuring heights, is much more affected by the alteration in the specific gravity of the air by the existing temperature, than by that of the metal. He proceeds, "So that whether the tube expand or contract, or were it possible, do neither, whatever the material of which it is made, whatever its sectional form, equality or inequality of calibre, still the *absolute* dilatation and not the apparent must regulate the correction for difference of temperature."

It is evident that X. here speaks of the change in specific gravity as if it were to be ascertained by weight, and not by measure. He forgets that in the barometric experiment the only way in which the result is affected is by alteration of volume; which alteration of volume is ascertained by measure. Now as this measure cannot be taken upon any scale which is not itself liable to expansion and contraction from changes of temperature, it is clear that the alterations of the latter must be taken into account; so that if the expansion of the mercury be measured upon brass, the absolute dilatation per degree of the former must be taken *minus* that of the latter, or if it be compared with glass, *minus* that of the glass.

I shall leave MM. Dulong and Petit, whom your correspondent asserts are so "egregiously wrong," to defend themselves, should they think it worth while, being perfectly assured, in my own mind, that they are fully competent to the task; and I have not much doubt that even M. Biot would be able to rescue himself from the imputation of having made "a false conclusion from his own premises."

With regard to the filtration and distillation of mercury, I must beg to assure X. that notwithstanding his knowledge of that metal "derived from a peculiar application of it," he may acquire much further information by inquiry of any competent workman.

If I shall have succeeded in making myself intelligible to X. I may, perhaps, be permitted to hope, that he will see the propriety of hereafter excluding from scientific controversy such expressions as that of "mere drivelling."

I remain, Gentlemen, with great esteem,

Yours faithfully,

J. F. Daniell.

Article VIII.

New Researches on the Sulphuric Acid of Saxony. By M. Bussy.*

We have given an account in the present number of the *Annals* (p. 307), of M. Bussy's experiments on anhydrous sulphurous acid. He has lately examined the properties of the fuming sulphuric acid from Nordhausen, which is prepared by the distillation of green vitriol previously deprived of its water of crystallization. The results which M. Bussy obtained confirm the statement given by Dr. Thomson (System, vol. ii. p. 113), that the fuming property of the Nordhausen acid is owing to its containing a portion of anhydrous, or absolutely pure sulphuric acid, which may be separated by distillation. The properties of the anhydrous sulphuric acid (which, as our readers know, is a crystalline solid), as detailed by M. Bussy, agree very nearly with the account given of it by Dr. Thomson. We proceed to give a short extract of the most important and novel parts of M. Bussy's researches.

The Nordhausen acid boils at first at a temperature between 104° and 122° Fahr. A portion flies off in thick vapours, and when these cease to come over, a very considerable increase of heat is requisite to maintain the ebullition of the liquid, which is now reduced to the state of common sulphuric acid.

When the anhydrous acid is exposed to the air, a portion evaporates at ordinary temperatures, and the remainder gradually attracts moisture, and is converted into common liquid sulphuric acid; it chars vegetable substances, such as paper and wood, the instant it comes in contact with them. No gas is disengaged by the action of the concrete acid on water; and M. Bussy ascertained that it is perfectly anhydrous by passing its vapour over caustic barytes, slightly heated in a glass tube, connected with a mercurial apparatus; a lively incandescence of the whole mass ensued, but neither sulphurous acid nor any other gas was given out. Nothing but sulphate of barytes was formed, perfectly free both from sulphite and sulphuret. By the mean of three experiments, 100 parts of concrete acid gave 288·6 parts of sulphate of barytes, which is composed of 78 parts of base united to 40 parts of dry sulphuric acid; therefore the concrete acid must have contained 97·8 parts per cent. of real acid, and 2·2 water. But the smallest proportion in which water can combine with dry sulphuric acid is that of 9 : 40, and 100 parts of such acid contain 18·36 parts of water; consequently the concrete acid contains none that properly belongs to its composition; and the minute quantity of 2·2 per cent.

* Journal de Pharmacie.

must be ascribed to the unavoidable errors of experiment, and the impossibility of preventing the concrete acid from attracting some moisture during the course of it.

The anhydrous acid liquefies at about 66° Fahr.; it is more fluid than common sulphuric acid, and has a high refractive power; at the above temperature its specific gravity is 1·97. To preserve it in the liquid form, it must be kept at the temperature of 77° Fahr; below that point silky tufts are seen to form, and the liquid soon becomes quite solid; when it has once assumed that state it is difficult to remelt it, for the portions which receive the first impression of the heat are volatilized and lift up the incumbent mass, sometimes throwing it out of the vessel to the manifest danger of the operator. It may, however, be liquefied by the assistance of a slight pressure.

Anhydrous sulphuric acid dissolves iodine, with which it forms a greenish blue solution.

Action of Heat on Sulphate of Iron, and the other Sulphates decomposable by Heat.

When crystallized protosulphate of iron is exposed to the action of heat in close vessels, it first loses its water of crystallization, which amounts to about 45 per cent. and becomes a white anhydrous protosulphate, composed of 28·96 of sulphuric acid and 26·04 of protoxide of iron. If the heat be continued, sulphurous acid is disengaged, and then very thick and suffocating vapours, which act on mercury if we attempt to collect them over that fluid; to prevent which it is necessary to wash the gas before it is collected.

"The apparatus which I use consists of a glass retort, whose beak is drawn out by the lamp, and passes into a vessel filled with distilled water at 122° Fahr. From this vessel proceeds a bent tube, which passes under a jar, filled with and inverted over mercury.

"By gradually heating the retort to redness, at first only sulphurous acid gas comes over; after a short time it is mixed with a certain quantity of oxygen, which continually increases to the end of the operation. The collected gas, when examined by potash, is found to consist of two parts of sulphurous acid gas and one of oxygen. The water contains some sulphuric acid, and peroxide of iron, sometimes still retaining a little sulphuric acid, remains in the retort."

What passes in this operation is thus explained:—"At first a portion of the sulphuric acid is decomposed into sulphurous acid and oxygen, which raises the iron to the maximum of oxidation; another portion is volatilized, undecomposed, and dissolved by the water; and a third portion is decomposed by the heat into two volumes of sulphurous acid and one volume of oxygen."

"If the persulphate of iron be employed, sulphurous acid and oxygen gases are obtained from the first, in the proportion of two to one, and the white vapours, whose solution in water constitutes sulphuric acid, are evolved at the same time."

To ascertain if the sulphuric acid be disengaged as such from the sulphate, or formed by its contact with the water, the same apparatus was used, except that the water vessel was replaced by a small perfectly dry matrass, immersed in a mixture of ice and salt, and having a bent tube for the escape of the incondensible gases. The heat was applied as before; oxygen gas was given off during the whole process, but no sensible quantity of sulphurous acid, and very few white vapours. After the operation, the matrass contained a colourless, transparent liquid, of the specific gravity of 1·85; it gave off excessively abundant white vapours, and by exposure to the air a portion of it evaporated, and the rest crystallized. The crystals, which were at first opaque, afterwards became transparent, and finished by melting into liquid sulphuric acid. When left in an open vessel, in which the air could not readily be renewed, it sublimed, and crystallized like benzoic acid; placed in contact with water it produced strong explosions, sulphurous acid was disengaged, and the liquid contained sulphuric acid; the addition of concentrated sulphuric acid also occasions a great evolution of sulphurous acid gas; if the acid be cautiously added, and in small quantity, transparent crystals are obtained; lastly, when this acid is passed in the state of vapour over previously heated caustic barytes, it is converted into sulphate and sulphuret.

"All these properties led me to suppose that this substance might be hyposulphuric acid, which was converted by contact with water or salifiable bases into sulphuric and sulphurous acid; but I soon found that it is merely a mixture of those two. When distilled, and the product received in a cooling mixture, the liquid boils at a temperature between 37° and 39° Fahr. If the products be received separately, what comes over at first at a low temperature is merely liquid sulphurous acid, scarcely exhaling any white vapours, and wholly convertible into gas, at common temperatures, with the peculiar odour of sulphurous acid. If the distillation be stopped when the first portion has come over, the remainder crystallizes in small delicate needles, and has all the characters of anhydrous sulphuric acid. Alum, and the sulphates of copper, zinc, and antimony, and generally all the sulphates decomposable by heat give, by similar treatment, similar results."

This fuming liquid dissolves indigo instantly without the application of heat, and affords a magnificent purple solution, precisely similar in colour to the vapour of indigo. When the purple solution is exposed to the air, it attracts moisture, the acid becomes common sulphuric acid, and the solution turns

blue: the same effect is produced by the addition of common sulphuric acid; the liquid, however, always retains a sensible tint of red, especially when seen by transmitted light.

Of the Manner of obtaining the Fuming Acid of Saxony.

"We have seen that the Nordhausen acid differs from the common by containing a larger proportion of real acid, and that the anhydrous acid may be obtained by the distillation of dry sulphate of iron; consequently we may obtain the acid of every degree of strength, by properly receiving the products of that distillation."

By distilling persulphate of iron, in the manner already described, and receiving the product in distilled water, an acid was obtained, which marked 20° of Beaume's areometer (= specific gravity of about 1·167). By frequent repetitions of the process, and always condensing the vapours in the same liquid, an exceedingly fuming acid was obtained, similar to that from Nordhausen in all respects, except in colour. But the most economical method of preparing the Nordhausen acid is to receive the product of the distillation of sulphate of iron in common sulphuric acid of the specific gravity of 1·844.

But in operating on a large scale, a difficulty occurs when we attempt to pass the vapours into common sulphuric acid, from their corrosive action, assisted by the necessary pressure, on the lutes and joinings of the apparatus; for if pressure be not employed, a large portion of the sulphuric acid is carried off by the sulphurous acid and oxygen gases, which are disengaged at the same time, but not condensed.

"To obviate this inconvenience as far as possible, the apparatus should be so constructed that the vapours may be disengaged through a narrow orifice, and their points of contact with the acid multiplied. For this purpose, I use a retort with an adopter, the end of which is slightly drawn out; to this I adapt a quilled receiver, and to that a tubulated one. The acid to be saturated is put into these receivers. Operating in this way, 20 parts of desiccated sulphate of iron converted 7·5 parts of common, into 10 parts of very fuming sulphuric acid.

"When a large excess of sulphuric vapours are passed into common acid, in order to have it as concentrated as possible, it is obtained crystallized at common temperatures in fine, transparent, very fuming crystals. It is difficult to ascertain their specific gravity, but I found that of the supernatant liquid to be 1·907, which, I believe, is less than it would be if it were perfectly free from a portion of sulphurous acid.

"I placed common sulphuric acid, specific gravity 1·845, in a flask, and poured over it liquid, anhydrous sulphurous acid, and slightly agitated the two liquids; a portion of the sulphurous acid dissolved, and the rest remained on the surface, without

mixing with the sulphuric acid; but by continuing the agitation a portion of the sulphurous acid was interfused amongst the sulphuric, and gave it that sort of opacity which oil imparts to water. By repose, the acids separated again, the sulphuric subsiding and resuming its transparency. After the operation, the sulphuric acid had a strong odour of sulphurous acid; its specific gravity was diminished, and it exhaled no white vapours."

The density of the Nordhausen acid should exceed that of 66° of Beaume's hydrometer (= specific gravity 1·848), it should be as high as 68° (= about specific gravity 1·900).

" Although the fuming sulphuric acid be not much employed, it would probably come into more frequent use if it could be obtained at a lower price; for it possesses very valuable properties, especially to the manufacturer of dyed cloths, and to dyers in general; since it dissolves a much larger quantity of indigo than the common acid, and is very superior in regard to its acidity; and, as in many cases, this acid solution of indigo cannot be employed on account of its action on the cloth, or the other colours, it is converted into acetate of indigo by precipitating the sulphuric acid by means of acetate of lead. It is obvious, therefore, that it must be extremely advantageous to dissolve the greatest possible quantity of indigo in a given quantity of acid."

" It results from what has been stated above,

" 1. That the fuming sulphuric acid of Nordhausen is merely common acid, containing a certain quantity of anhydrous acid, to which it owes its characteristic properties; that the sulphurous acid is only an accidental ingredient, and does not essentially affect its properties.

" 2. That the anhydrous acid may be separated by distillation, and that it possesses, amongst other remarkable properties, that of forming a red solution of indigo.

" 3. That all the sulphates, decomposable by heat, give off oxygen, sulphurous acid and sulphuric acid, which is essentially characterized by the white vapours that are produced during the decomposition.

" 4. That all those sulphates may be used in preparing both the common and the fuming sulphuric acid, by means of the process which has been described above."

Article IX.

Remarks on the Construction of Vessels. By Col. Beaufoy, FRS.

(To the Editors of the *Annals of Philosophy.*)

DEAR SIRS, *Bushey Heath, Stanmore, Sept.* 13, 1824.

The readers of the *Annals of Philosophy* will be gratified to learn, that the Admiralty, in addition to the improvements already introduced into the navy, have given orders for building three vessels (the Orestes, Champion, and Pylades) upon different principles, suggested, I believe, by Prof. Inman, Capt. Hayes, R. N. and Sir Robert Seppings. As these ships have nearly equal length, breadth, and tonnage; * and as great theoretical knowledge and ability will be exercised in giving to every vessel that form which each individual considers the most advantageous; much valuable information for the future advancement of naval architecture may be expected from the above collision of intellect.

When these ships proceed to sea for the purpose of comparing their respective qualities, it is possible considerable difference will be found in their sailing. This inequality may proceed from dissimilarity in the length of the masts and yards, and consequently in the size of the sails. The bow of one may be better adapted than the others for dividing the water, or the after part may possess a more efficacious shape. The stowing of the ballast, the smoothness of the bottoms, or superiority of seamanship, will also severally produce a disagreement in their rates of sailing. The latter point can, however, be detected, by changing the officers from ship to ship. An alteration in the distribution of the ballast will produce a correspondent fluctuation in the merits of each vessel; the best sailor becoming worse, and the dull better; but with respect to the fore and after bodies, how far the particular form of each contributes to the fast sailing, it will be impossible to judge from want of sufficient knowledge of the resistance of non-elastic fluids. This branch of mechanical science being very imperfectly understood, it cannot be expected

	Orestes.		Champion.		Pylades.	
	Feet	In.	Feet	In.	Feet	In.
* Length on deck.....	109	11	109	6	110	1
Breadth extreme.....	30	6	30	6½	30	¼
Depth in hold.....	7	6	7	8¼	8	2
Builder's tonnage	460	0	456	0	433	0
Light draft of water.. Afore.	8	6	10	8	8	8½
Light draft of water.. Abaft.	11	0	10	10	10	11

that the shape of vessels can be advantageously altered, until the improvement is founded on the solid basis of experiment. Then, and not before, constructors will be able to give satisfactory reasons for adopting one form in preference to another.

To place in a conspicuous point of view the various opinions which writers on naval subjects entertain respecting the resistance of water, I will commence with the remarks of Monsieur Romme, Correspondent de l'Académie des Sciences de Paris, et Professeur-Royal de Navigation des Eleves de la Marine. This gentleman, in the year 1787, published a quarto book on naval affairs; and therein states, that the resistance a vessel meets when sailing is almost independent of the form of the bow; the impulse of the water being the same, provided the greatest vertical section remains unaltered. And this theory is represented as confirmed by experiment, made with two models of a seventy-four gun ship; one model had the bow formed in the usual manner with curved lines; the other had a similar midship bend, but the bow consisted of strait lines; yet notwithstanding this great dissimilarity of shape, both were equally resisted when moving with equal celerity. M. Romme could not discover that these models experienced more or less resistance when either the stern or bow went foremost; nor was any alteration effected when the vessels were cut in two, and the head of one joined to the tail of the other.

Mr. Stalkartt, in his Treatise on Ship Building, recommends the segment of a circle as best adapted for dividing the water; and others prefer the parabola. Such contrariety of opinions only prove how little we know on the subject; and the importance of establishing some more correct rule for drawing the water-lines of vessels, than the mere fancy of the draughtsman.

The tonnage of the Royal navy in round numbers may be estimated at 450,000; the expense of building, taking one vessel with another at 20*l.* per ton; the value of all at nine millions. To the expense of the hulls must be added the cost of the masts, yards, sails, cordage, and many other et ceteras, requisite for the equipment; this doubles the amount, making 18,000,000 for the primary sum laid out on men of war. The durability of the ships in time of peace may be now calculated at 14 years; during war at 10 years; the average is 12 years; consequently 1,500,000*l.* of money is annually expended in keeping these bulwarks of the nation in an efficient state.

Every one will assent that the construction of such costly machines should, in the first instance, be as perfect as possible; hence arises the question, how, and at what expense, is so desirable an end to be accomplished? The increase of $\frac{1}{1800}$th part of the annual expenditure, would secure this point; for the application of the comparatively small sum of 1000*l.* in making

a complete set of experiments, in all probability, would be attended with most beneficial results for the future construction of ships.

Let it be borne in mind the sums of money which are year after year laid out to encourage a superiority of far less moment to the United Kingdom than the excellence of the navy: there are plates, sweepstakes, and purses, for breeding fleet horses; in a national point of view, it is of little consequence whether the average rate of a racer be 37 or 38 miles in the hour; but widely different is the case, if the sailing of our men of war be increased one knot, or half a knot, in the same space of time. By such improvement an enemy's fleet may be taken, or an island captured, or a colony preserved; and who would not rather read in the Gazette a dispatch from an Admiral, stating that in consequence of the superior sailing of his fleet he had come up with, and captured the enemy, than peruse in the public papers that at Newmarket, or any other celebrated racing ground, after a well contested run, one horse was declared the winner by half a neck, and the prize adjudged accordingly.

If the union of capacity with quickness of sailing be deemed impracticable, the error of such opinion is fully demonstrated by reference to the engravings accompanying a work on the Elements and Practice of Naval Architecture, by Mr. David Steel; who there gives the draught of a London trader particularly distinguished for capacity and velocity;—a circumstance the more remarkable in a merchantman, as the variety of the cargoes would be tantamount to alteration of stowage; and consequently if the same vessel, under such circumstances, continues to remain a prime sailor, it is evident this superiority depends on the curves that divide the water.

Discoveries are continually making in chemistry, magnetism, and galvanism; improvements are introduced in chronometers, and mathematical instruments; all these advantages proceed either from experiment or observation, and it only requires the powerful influence of my Lord Melville, to expel, by similar means, the mist that at present envelopes the science of hydrodynamics; and to place this neglected branch of knowledge in the elevated situation it so justly merits from its importance to a maritime nation. I remain,

Dear Sirs, yours very truly,

Mark Beaufoy.

Article X.

Description of a Process for making Damasked Steel. By M. Breant.*

It appeared from M. Breant's former experiments, published in the "Bulletin de la Societé d'Encouragement," for 1821, that the watered or wavy appearance on the eastern damasked steel is not mechanically produced, but the result of a particular composition, and he has at length ascertained that it is owing to an increased quantity of carbon incorporated with the steel beyond the proportion contained in the common sorts. According to this chemist, the effect depends on two states of combination in which the carbon exists in the steel, and numerous experiments have enabled him to give the rules for several processes for the manufacture of different kinds of cast steel.

"The watered (*moirée*) surface of the oriental sabres has led to the supposition that they are made from what is called *stuff* (*etoffe*), that is a bundle of steel bars, or wires, forged and welded together, and twisted in different directions.

"A long series of experiments has taught me that the substance of the oriental damask is a fused steel, more loaded with carbon than our European steels, and in which, by means of a proper management in the cooling, a crystallization of two distinct compounds of iron and carbon is affected.

"This separation is the essential condition; for if the fused matter be suddenly cooled, as is the case when cast into small ingots, no appearance of damask is perceptible; it is only to be discovered by using a magnifying lens.

"Iron and carbon form at least three distinct compounds; steel, which is at one of the extremities of the series, contains but a very small proportion (1-100th) of carbon; plumbago, on the contrary, contains from 12 to 15 times more carbon than iron. Black and white cast iron hold the middle place."

As bodies combine chemically only in definite proportions, if in making steel there be a deficiency of carbon, a portion of the iron will remain merely in a state of mixture with the steel that is formed, the quantity of the latter depending on the quantity of combined carbon; and on cooling the mass slowly, the more fusible particles of steel will have a tendency to unite together, and separate from the iron. This alloy, therefore, will show a damasked surface, but it will be white, ill defined, and the metal being mixed with iron will not be capable of much hardness.

The exact proportion of carbon requisite to convert all the iron into steel will give a homogeneous mass; and conse-

* From the Annales des Mines.

quently no separation of distinct compounds can take place on cooling. "But if the carbon be in slight excess, the whole of the iron will first be converted into steel; then the free carbon which remains in the crucible will combine in a new proportion with a part of the fused steel already formed, and there will thus be two distinct compounds, pure steel, and carburetted or cast steel. These two compounds, at first indiscriminately mingled together, will tend to separate as soon as the liquid matter is at rest, and crystallization will ensue, during which the molecules of the two compounds will arrange themselves according to their respective affinities and weights.

"If we dip a blade made of steel thus prepared in acidulated water, a very evident damask will be developed, in which the portions of pure steel will be black, and those of the carburetted will remain white, because the acidulated water does not so readily lay bare the carbon of the carburetted steel as of the pure.

"It is, therefore, to the irregular division of the carbon by the metal, and the formation of two distinct compounds, that the production of the damasked surface is to be attributed, and it is obvious that the more gradually the mass is cooled, the larger will be the veins of the damask. It is, perhaps, for this reason, that we should avoid fusing the substance in too great a mass, or at least that some limit should be observed in the process; in support of which opinion I may quote Tavernier, who has given in his "Voyage en Perse" some information as to the size of the balls of steel, which, in his day, were used in making the damasked blades.

"The steel capable of being damasked comes, says he, from the kingdom of Golconda; it occurs in commerce in masses of the size of a halfpenny loaf; they are cut in two to see if they be of good quality, and each half makes one sword blade.

"From this account it is evident, that this Golconda steel was in buttons like *wootz*, and that each button could not have weighed more than five or six pounds.

"Tavernier adds, that if this steel were tempered by the European processes, it would be as brittle as glass. Hence, as Reaumur observed, it must be very difficult to forge.

"That philosopher having received some specimens of Indian steel from Cairo found no one in Paris who could forge it; whereupon he laid the blame on our workmen; since the inhabitants of the east know how to work that kind of steel. I will explain presently the proper method of proceeding to ensure success.

"As carbon has the chief influence not only in producing the damask on steel, but also on its intrinsic qualities, I fear that Messrs. Stodart and Faraday were led into error in their experiments (as I, for a long time, was myself), and attributed effects

to metallic alloys which were owing more particularly to an increased proportion of carbon.

"I am very far from disputing the existence of metallic alloys in the oriental sabres, although, in the few fragments which I have had an opportunity of examining, I have not found either silver, gold, palladium, or rhodium; I think it very probable, however, that different combinations may have been attempted. A people who knew how to harden copper by alloying it with other metals, are very likely, from analogy, to have tried the same process with iron.

"This view of the subject led me to form various metallic alloys, some of which gave satisfactory results. One of the sword blades which I presented to the Exhibition contains one-half per cent. of platina, and a larger proportion of carbon than common steel; its damask is owing particularly to the latter. Excellent razors have been made with this alloy.

"At all events these alloys should not be tried till we have fully ascertained the effects of pure carbon, and we ought to begin by combinations in very small proportions. The addition of a metal makes the steel more brittle; however, I have obtained ductile alloys, in raising the quantity of gold and platina, as high as 4 per cent. and that of copper and zinc to 2.

"As to zinc, certain precautions are necessary in forming alloys with that metal; it occasions violent detonations, wherefore it must be added to the fused metals in very small portions at a time. In forging steel alloyed with zinc, part of the metal is volatilized and dissipated.

"Manganese unites readily with steel, and the alloy forges easily; but it is very brittle when cold: I have made gravers with this alloy which cut iron without having been tempered: the damask of this mixture is very black and well defined.

"Plumbago appeared in some instances to soften steel which had been rendered too brittle by an excess of carbon; at least I have obtained excellent results with 100 parts of steel, 1 of lamp-black, and 1 of plumbago.

"But a very remarkable experiment, from the advantage that may result from it in working on a large scale, is one which showed that 100 parts of soft iron and 2 of lamp-black fuse as readily as common steel. Probably the whole of the carbon does not combine. Some of our best blades are produced from this combination. It has the disadvantage of contracting very much on cooling, and the buttons generally have cavities which make them very difficult to forge; but if, instead of damasked, we only want to make common steel, the contraction on cooling may be prevented by casting this compound in an ingot mould.

"This experiment teaches us that the previous cementation of the iron is not necessary in order to obtain very good steel.

It may be treated at once with lamp-black, which will very much lessen the expense of the manufacture.

"One hundred parts of very grey cast iron filings, and 100 parts of the same filings previously oxidated, gave a steel of a fine damask, and calculated for sword blades, &c. It is remarkable for its elasticity, an important quality in which the Indian steel is deficient. I have always operated on three or four pounds at a time. The larger the proportion of the oxidated ingredient, the tougher (*nerveux*) is the steel. The oxygen combining with the metals of the earths, and part of the carbon, it is obvious that the more oxide there is, the more ductile will be the result; but it will also be softer. The blackest cast iron answers best. I am convinced that with that substance we may make cast steel in reverberatory furnaces on a very large scale, by adopting a process analogous to that used in refining bell metal, namely, by adding to the fused metal a portion of the same metal oxidated; or, still better, native oxide of iron.

"It seems to me to be equally practicable to convert the whole of the product of the Catalonian forges (*forges à la Catalane*) into cast steel, by altering the construction of the furnaces so as completely to fuse the metal. I think if I had the direction of one of those forges, I could find means to manufacture steel of the most desirable quality with great saving of expense.

"I have always been careful to stir the fused metal thoroughly before I suffered it to cool; this is indispensable in making metallic alloys, for without it the damask is not homogeneous.

"It was after I had attempted to combine steel with aluminum and silicium, that I observed the influence of carbon in producing the damask: from that time I always used the carbon of lamp-black.

"If some earths be found on analyzing my cast steel, they must probably be attributed to the cast iron employed, or to the iron, the plumbago, or the crucibles.

"The more carbon a steel contains, the more difficult it is to forge. The greater number of those that I have prepared can be tilted at only very limited temperatures. At a white heat they crumble under the hammer; at a cherry-red they become hard and brittle, and this quality increases in proportion as the temperature diminishes; so that when once it has fallen below cherry-red, if we endeavour to cut it with the graver, or the file, we find it much harder and more brittle than after it is completely cold.

"It is evident that the Indian steel, which most of our workmen are unable to forge, is similarly circumstanced; and if the Indians work it without difficulty, it is because they know the limits of temperature within which it is manageable.

"I am convinced from experience that the orbicular veins,

which the workmen call brambles (*ronce*), and which are seen on the beautiful Indian blades, are the consequence of the way in which they are forged. If steel be drawn out lengthwise, the veins will be longitudinal; if it be equally extended in all directions, the damask will have a crystalline appearance; if it be rendered wavy in both directions, it will be shaded like the eastern damask. But few trials are necessary to produce any sort of watering that may be desired.

"The best process for developing the damask, so that the steel may become black or bluish without losing its polish, is, in my opinion, that which is employed in the East. It is described, by M. le Vicompte Héricart de Thury, in a report inserted in the 'Bulletin de la Société d'Encouragement,' No. 220, for December, 1821, twentieth year, p. 361."

Article XI.

The Bakerian Lecture.—On certain Motions produced in Fluid Conductors when transmitting the Electric Current. By J. F. W. Herschel, Esq. FRS.

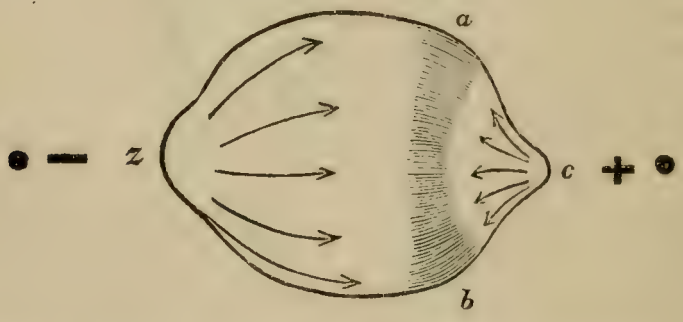
(*Concluded from* p. 176.)

17. In many liquids, and especially in solutions of the nitrates, there is formed not only a current radiating from the negative pole, but also one from the positive, which even has in some cases a preponderance over the other. These co-exist in the mercury; and, in consequence of their action, a zone of equilibrium is formed in the globule, nearer to one or the other pole, as the antagonist current is more or less violent. The best way to render the influence of this counter-current sensible is to operate on a large quantity of mercury, under dilute solutions, keeping the negative pole at a distance, and the positive very near. In this way there are few liquids which, when the pile is in good action, do not show some signs of a counter-current from the positive pole. The cause of this will be evident, when we come to speak of the action of metallic alloys.

18. If either pole be brought in contact with the mercury, no currents are observed from the point of contact (at least when the mercury is fresh and the contact perfect) but strong ones are always produced, radiating from the other. If it be the negative pole which is made to touch, it amalgamates with the mercury, which remains bright, and the currents radiating from the positive are visible to the eye, and generally very powerful. On the other hand, if the positive pole be in contact, the oxidation of the metallic surface is usually so rapid as to prevent the currents becoming visible, but a momentary start of the surface

from the negative wire, the flattening of the globule, and the protuberances it throws out in pursuit of the oppositely electrified conductor, sufficiently indicate their existence under the crust of oxide. Where this oxidation however does not happen, or is prevented by the addition of a few drops of dilute nitric acid, the currents from the negative wire are equally evident with those from the positive, just mentioned.

19. These however are not the only effects produced by contact with the electrified wires. On breaking the contacts and completing the circuit in the liquid, the mercury is found for the most part to have acquired new properties, or lost some of its former ones. A globule of four or five hundred grains of pure mercury being introduced into a solution of sulphate of soda, the circuit was completed in the liquid with neither pole in contact. A current was produced from the negative pole. A momentary contact being made with that wire, and the circuit then completed as before in the liquid, a counter-current was produced from the positive pole, more confined in the sphere of its extent, but apparently more violent in its action than that from the negative. In consequence, the globule acquired the figure here annexed, having a blunt elongation at z, the point nearest the negative pole, and a more pointed one at c, that next the positive, with a kind of shoulder at $a\ b$. The film of oxide produced at z was thus swept towards c, but never attained beyond



the zone $a\ b$, where it remained stationary and constant in quantity, being absorbed at the side next c as fast as it was produced at the other. Another short contact was now made with the negative wire, and, on breaking it, the currents from c were found to have increased both in strength and extent, while those from z were proportionally enfeebled, the zone of equilibrium $a\ b$ being thus brought nearer to z. By another contact prolonged a few seconds, the negative currents were contracted within a very small space around z, and by prolonging the contact a little longer, its influence was totally destroyed, and a regular and violent circulation from + to − established throughout the whole globule.

20. But the effects did not stop here. On prolonging the contact a considerable time, the negative current (from z) was not only wholly destroyed, but changed into one of a contrary tendency; *i. e.* radiating in all directions to z; the particles of the mercury appearing to be attracted to that point with a force equal, or superior, to that with which they were repelled from c. The positive pole being held at some distance, and the negative directly over the surface, any scum or impurity on the mercury was observed to collect directly under it, in a small circular spot, following exactly its motions; and when this was cleared away, the fluid metal was violently thrown up towards the wire in a jet of two or three-tenths of an inch in height.

21. The mercury was now brought into contact with the positive wire. Visible oxidation did not commence on its surface for a long while, during which time violent currents still continued to radiate in all directions from the wire and *towards* the point z (or in a direction opposite to what they would have taken in untouched mercury). By degrees, however, a counter-radiation, commenced opposite to the negative pole, whose sphere was at first very limited, but gradually extended, producing a zone of equilibrium, which advanced rapidly towards the positive wire, and at length attained it. The instant this took place, the oxidation of the mercury commenced at z, and speedily extended over the whole surface, forming a thick crust.

22. If the contact of the positive pole was continued long enough, the mercury, on cleansing it from its coat, was found reduced to its former state, as if freshly introduced; but if broken as soon as the crust was fully formed, a radiation from the negative wire was produced, and the crust broken up and swept by it to c, where it collected, and was hurried off. But the moment this was done, and the surface of the mercury had become bright throughout, it stopped for an instant, and immediately a violent revulsion took place, and a powerful current radiated from c, that from z being annihilated.

23. These effects, when first observed (not connectedly in regular succession, as here set down, but piece-meal), appeared exceedingly perplexing; but the key to them was soon found. I observed that the effect of a contact of the negative pole was proportionally stronger in producing a positive radiation, as the mercury had been allowed to circulate longer before the contact was made, and, on more close examination, I found that the platina wire terminating the negative conductor of the pile, had got amalgamated with a little mercury, which, during the time the circuit was completed in the liquid, had become alloyed with sodium; and, with the quantity of this metal judged to be present, the effect seemed always to be in proportion. I had no hesitation, therefore, in attributing all the new properties acquired by the mercury to the presence of sodium, and on

introducing into a quantity of the pure metal a small quantity of an amalgam of this substance prepared for the purpose, I found my supposition verified; a most violent negative rotation being immediately produced on completing the circuit, without allowing either wire to touch the mercury.

24. The presence of this highly electro-positive metal therefore counteracts the effect of the negative pole, and exalts that of the positive in a degree proportioned to its quantity, till at length it completely overcomes, and even reverses the former effect. As the quantity (in the foregoing experiment) diminished in the alloy by the oxidating action of the positive pole, the mercury, as we have seen, by degrees resumed its original properties. The only effect that may appear obscure is the revulsion noticed in the direction of the currents when the last portion of oxide disappears. It is, in fact, a pretty complicated effect, but capable of easy explanation. The oxidation takes place over the surface of the metal before the last portions of sodium are removed. This is easily proved. We have only to break the circuit altogether, and the crust of oxide will gradually disappear (unless suffered to go too far), being reduced by the sodium beneath it. Were it not then for the crust of oxide, the currents, as has been seen, would be in a positive direction. But the oxide, acting on the stratum of metallic molecules immediately below it, deprives them of their alloy, which it converts into alkali, leaving a stratum of pure mercury. Now we have seen that in *this*, the rotation, in the circumstances of the experiment, would have a negative direction. We have only then to admit that the peculiar action by which the rotations are caused, is confined to the common surface of the mercury and liquid, to have a perfect idea of the mode in which the whole process is carried on. The stratum of pure mercury on the surface is removed by a negative current agreeably with its natural relations, and immediately succeeded by a stratum of the sodiuretted metal from the interior; this, in its turn, is deprived of its sodium by the oxide in contact with it, and is immediately radiated off like its predecessor, and so on till the whole crust of oxide is exhausted or swept off, when the remaining mercury, still retaining an excess of sodium, and instantly rendered homogeneous, is acted on as an alloy, in the way already described.

25. That sodium is actually present in the mercury when it has acquired the property of producing currents from the positive pole (which for brevity I will hereafter call the positive property) by contact with the negative wire, may be shown by a very simple and interesting experiment. When the negative wire is detached and the circuit broken, the mercury lies quiet at the bottom of the vessel, with the exception of a slight irregular motion on its surface, and now and then a minute gas

bubble disengaged. Now touch it under the liquid with a clean metallic wire of any kind (provided its extremity be not allayed with sodium), and a violent action instantly commences. The mercury rushes on all sides to the wire in a superficial current as if to give out its sodium, while a copious stream of hydrogen is given off from the wire, not merely at the point of contact with the mercury, but wherever it touches the liquid. In a word, the sodium, the wire, and the liquid, form a voltaic combination, and the electricity produced by the contact is sufficiently powerful to decompose the aqueous portion of the latter in great abundance. The action lasts for a longer or shorter time accordingly as the mercury is more or less highly charged with the alkaline metal, rarely, however, for more than 10 or 12 seconds, and, when over, the mercury is found to have lost its positive property, and to be reduced to its pristine state (provided the contact be made with copper or platina), which a long immersion in the fluid without such contact would not have entirely effected.

26. If the mercury thus charged with the alkaline base be not entirely covered with the fluid, and the metallic contact be made at the vertex of the globule, out of the liquid, no effect is produced; but if the other end of the metallic wire be bent round and brought to touch the liquid at some distance from the mercury, the violent action above described immediately commences; with this difference, that *now* the surface of the mercury is radiated in all directions *from* the point of contact to the circumference of the globule, and that the whole of the hydrogen is given off at the other end of the wire where it touches the liquid. A little consideration will suffice, however, to show that both these effects are merely modifications of one and the same. It is not to, or from the *wire* as such, that the superficial particles radiate; they merely follow the direction of the predominant electric currents in their passage *through the liquid*. It is in fact the case of the source of positive electricity, being the mercury itself, instead of its being conveyed to it from a pile at a distance.

27. Having thus distinctly traced the alteration in the mechanical effect by contact with the negative pole, to the amalgamation of the mercury with sodium, the knowledge of this fact led me to investigate more minutely the effects of different metals in their contact and amalgamation with mercury; and the results I have encountered in the course of these inquiries, appear to me so remarkable, that I cannot forbear annexing them, especially as they afford an explanation of almost every anomaly which perplexed me in the commencement of the investigation. In order to render the effects less liable to objection, as well as more distinct and striking, I now used solutions of potash or

soda, pretty highly impregnated with the caustic alkali, for the conducting liquid. This has the advantages at once of high conducting power, and of producing no currents whatever in pure mercury, neither pole being placed in contact. Of course, whatever motions arise on the introduction of an extraneous metal must be due entirely to the presence of that metal, and the mercury may be regarded as merely passive, so far at least as mechanical action is concerned.

28. *Potassium.*—A contact of a single second's continuance with the negative pole of a pile of eight pairs, in feeble action under liquid potash, imparted to 100 grains of mercury the property of rotating violently from the positive to the negative pole, the circuit being completed in the liquid alone. The rotation was forcible when this alloy was diluted with 100 grains more of pure mercury, and was still sensible after the addition of another equal quantity. In this latter case, the quantity of potassium present could hardly be estimated at a millionth part of the whole mass.

29. *Sodium.*—Under a solution of soda I electrised 100 grains of mercury during 80 seconds with the above-mentioned Voltaic power, the mercury being in contact with the negative wire. It was then washed hastily, and introduced under a glass bell into dilute muriatic acid, which disengaged 95 mercury grain measures of pure hydrogen. Consequently, it contained less than $\frac{1}{30}$ of a grain of sodium; and as in such extremely small quantities the production of the alloying metal must go on uniformly, a contact of 1″ would have produced only $\frac{1}{30}$ of the quantity, or $\frac{1}{4000}$ of a grain; that is $\frac{1}{4000000}$ of the whole mass. This being premised, a contact of 1 second in duration was made under similar circumstances with 100 grains of fresh mercury, which was thus found to have acquired a powerful rotatory property. This was now diluted with 100 grains more of the pure metal, in which, therefore, the sodium was only in the proportion of 1 to 800,000. The rotation was enfeebled, but was still full and distinct. Being again diluted with 100 grains more of mercury, so as to make the proportion of sodium 1 : 1,200,000, there was still a considerable radiation from the positive pole, but not extending over the whole surface. On reducing the proportion of sodium by a third addition of an equal quantity of the pure metal to 1 : 1,600,000, a feeble radiation was still sensible in the same direction.

30. *Ammonium.*—A considerable quantity of the amalgam of this singular substance introduced into mercury under a solution of soda *did not communicate to it any power of rotation.* This remarkable result, which goes to separate ammonium by a definite character from the other metallic bases of the alkalies, was again obtained on repeating the experiment. It is possible,

indeed, that a complete insolubility of the amalgam in pure mercury may be the cause of this want of action, but the supposition must be allowed to be a very forced one.

31. *Barium.*—This metallic body amalgamates with the utmost readiness with a power of eight pairs of plates when the muriate is acted on; a small globule of mercury at the negative wire throwing out beautiful arborescences, and fixing into a highly crystalline, pretty permanent, solid amalgam. A very minute quantity of this introduced into mercury under solution of soda, gives it the positive property. Its efficacy, in reversing the direction of the currents, is strikingly sensible when introduced into a quantity of mercury kept in a state of negative rotation under oxalic acid. The amalgam of mercury and barium added in small quantities to pure mercury, imparts to it the same property as we noticed in the case of sodium, of forming a Voltaic combination with a wire brought in contact with it under a saline solution, and the action so produced is much more lasting.

32. *Strontium, Calcium.*—These metals, in my experiments with the feeble powers used, manifested a remarkable indisposition to alloy with mercury. The small quantity of calcium deposited on an amalgamated negative wire obstructed its contact with a larger globule of mercury to such a degree, that no electric communication could be established. Under a solution of strontia, the contact of the negative wire imparted the positive rotatory property sensibly, though very feebly. That this was not merely owing to the low conducting power of the liquid, was proved by introducing a minute quantity of the amalgam of zinc, when the mercury immediately commenced rotating strongly. The influence of *magnesium* is more sensible than that of strontium or calcium, from the greater readiness with which it amalgamates.

33. *Zinc.*—When pure mercury is electrified under solutions of potash or soda, with neither pole in contact, in the manner so often alluded to, it shows no signs of rotation, as has already been observed; but, if touched for an instant with the end of a clean zinc wire, or if an atom of the solid amalgam of zinc, the smallest that can be taken up on the end of a needle, be added to it, it instantly rotates violently in a positive direction (or from the positive pole).

34. An alloy of one part zinc to 10,000 of pure mercury rotates with the utmost violence. When this is diluted with ten times its quantity of the latter metal, the force of rotation appears but little impaired. The proportion of mercury was increased to 400,000 : 1, and the rotation, though feeble, was yet complete, pervading the whole of a considerable mass of the alloy; and even when the zinc amounted to no more than a 700,000th of the whole, a current radiating to a short distance

from the positive pole was still sensible: when, however, the zinc formed only a millionth part, no difference could be perceived between the alloy and pure mercury.

35. *Lead.*—An alloy of 200 parts of mercury and 1 of lead possessed the positive property in perfection. When the proportion of mercury was 667 to 1, the rotation was still produced, but was not full and regular. When increased to 1000, a slight, but sensible current, was perceived to radiate from the positive pole to a short distance; but a proportion of 2000 mercury to 1 lead extinguished every trace of motion.

36. *Tin* acts also in the same way, and with nearly the same energy, as far as I could judge by the eye. It is certainly much inferior to zinc.

37. *Iron* communicates the property in question, though present in such minute quantity as not to be detected by prussiate of potash. On the other hand,* *Copper* does not communicate it, though its proportion be increased to such a degree as to give a blue solution in nitric acid, and even to render the mercury quite sluggish.*

38. Of the other metals I have tried, *Antimony* is the only one which appears to exert a perceptible action, and this is so slight (never amounting to more than a mere start, or slight convulsion of the surface at the first impression) that I am inclined to attribute it to impurities in the antimony used, especially as this metal stands very low in the scale of electro-positive energy. Bismuth, silver, and gold, though present in considerable quantities in the mercury, impart to it no power of rotation whatever.

39. This property then of the metals bears an evident relation to their electro-positive energies. It even affords something like a numerical estimate of them; rude indeed, and liable to a thousand objections, but still not without its value in our present state of complete ignorance on that most interesting of all chemical problems. If it be true, that the whole of chemistry depends on electrical attractions and repulsions, every thing which offers a prospect, however remote, of one day arriving at an exact knowledge of the intensities of these forces, must be regarded as of consequence. It may be objected, that it is only the excess of the electro-positive energy of the alloying metal over that of the mercury, or the alloy over the liquid, that we measure in these experiments, by the quantity of it required to impart a certain appreciable momentum. Yet it is something to have rendered it probable, that this excess in the cases of sodium, zinc, and lead, are in proportions not *very* remote from

* The amalgam of iron obtained in one experiment was a white friable solid of a lustre between silver and iron: the mercury being driven off by heat, the iron took fire, and glowed like a live coal till reduced to the state of black oxide, soluble in muriatic acid, having all its characters.

1,600,000; 700,000; and 1000; or 1600, 700, and 1. The effect being purely mechanical, even the intensity of the motive forces exerted on a molecule of one of these metals could be determined, did we know the law of its action—but at least, in our ignorance of this, we are sure that it must be incomparably superior to gravity. A mass of mercury an inch in diameter alloyed with $\frac{1}{100,000}$ its weight of zinc, revolved with a motion so rapid as to complete the transfer of particles floating in the liquid in less than a second across its surface. Now, even if we were to take the supposition of a uniform acceleration of the motion of a molecule from one end to the other of this transfer, the intensity of gravity being taken at unity, that of the force accelerating each particle of the alloy would amount to $\frac{1 \text{ inch}}{16 \text{ feet} \times (1'')^2} = \frac{1}{12 \times 16} = 0{\cdot}00521$, and each particle of zinc being loaded with 100,000 times its weight of inert matter, the intensity of the force, acting on its molecules, cannot possibly be so little as 521 times their gravity. But it is in all probability immensely greater. So far from being uniformly accelerated along their whole course, the molecules, if narrowly watched, will be evidently seen to move with less and less velocity as they recede from their point of radiation; and it is assuming little to suppose their velocity at a hundredth of an inch from this point double of their mean velocity with which they traverse the diameter. To produce this effect, the force must (if supposed to act uniformly through *this* small space) be increased 100 fold, or to an intensity upwards of 50,000 times that of gravity. Such considerations tend, if I mistake not, greatly to enlarge our views of nature, and to prepare us for the admission of the most extravagant *numerical* conclusions respecting bodies less within the reach of our senses. That such minute proportions of extraneous matter should be found capable of communicating sensible mechanical motions, and properties of a definite character, to the body they are mixed with, is perhaps the most extraordinary fact that has yet appeared in chemistry. When we see energies so intense exerted by the ordinary forms of matter, we may very reasonably ask, what evidence we have for the imponderability of any of those powerful agents to which so large a part of the activity of material bodies seems to be owing?

40. I was anxious to examine whether similar motions would be produced in other metals than mercury and its alloys, when in fusion. The foregoing experiments, indeed, leave little room to doubt their capability to do so; but the nature of the case throws great difficulties in the way of direct experiment. I have been successful hitherto only in the case of the fusible alloy of lead, tin, and bismuth, no mercury being present. This, with a

little management, may be preserved tolerably clean of film and air bubbles, when kept in fusion under a boiling solution of sugar, acidulated with phosphoric acid, in which case the same circulation takes place as in the case of mercury, viz. from the negative to the positive pole. When solution of sugar alone however was used, the influence of the tin and lead became sensible, the predominant radiation being from the positive pole; a feeble counter-current being, however, observed from the negative.

41. The contact of the positive pole, in like manner, communicates peculiar properties to mercury, but less strongly marked, and which appear to depend, in part, on the film of oxide formed on its surface, and partly on an absorption of oxygen by the metal itself; a thing rendered not improbable by the analogy of silver and other metals, which, when fused in contact with air, absorb oxygen without losing their metallic appearance. The facts I have observed are chiefly these:

42. Equal quantities of mercury were electrified for equal times in two separate capsules, under similar solutions of carbonate of soda, one in contact with the negative wire, and the other with the positive. On mixing them together, the mercury was acted on as if pure, and showed no signs of containing sodium. Here, the mercury in contact with the positive pole had acquired a virtue capable of counteracting the effect of a considerable impregnation of sodium, which, had it not been counteracted, could not fail to be violent.

43. When mercury is kept in contact with the positive pole, the surface contracts a film of oxide of more or less considerable thickness. Now, break not only the contact, but the circuit. The mercury will be quite still; but the moment it is touched with a clean metallic wire (not electrified), the oxide disappears rapidly at the point of contact, as if absorbed, and the remainder rushes in on all sides to supply its place, producing a system of current in the surface radiating towards the wire. It is not indifferent with what metal the contact is made; potassium, sodium, barium, tin, and zinc, are those which produce the most violent action, the surface brightening instantly with a kind of flash like the *brandishing* of melted silver, tin being in this respect superior to zinc. The effect of iron is pretty considerable, that of copper less so, and of antimony and platina, none at all; neither had phosphorus any effect.

44. The effect, therefore, depends on the oxidability and amalgamating property jointly; and this points out the *modus operandi*. An amalgamation takes place at the point of contact, and this brings the oxidable metal into chemical contact with the oxide immediately around that point, which is instantly reduced. The motion of the surface is, however, doubtless an electric effect, for when mercury, *not* recently electrified is touched,

under acids, &c. with metallic wires, the effects are not the same. The contact of copper, for instance, produces an immediate, and even strong radiating current *from* the point of contact instead of *to* it, and this ceases the moment the contact becomes perfect by amalgamation, and cannot be renewed but by cutting off the amalgamated end, and making a fresh contact.

45. When mercury is electrified in contact with the positive pole under *certain* metallic solutions (nitrate of copper for instance), and the circuit broken, removing both wires, the current continues feebly for some time after the electric power is withdrawn, in the same direction, viz. from the point (z) opposite to the negative pole. By degrees, it grows more forcible, and a film formed during the electrisation is swept along to the point (c) opposite the former position of the positive wire, where it accumulates, leaving at length, the portion of the surface at z quite bright. As soon as this happens, the currents increase considerably in strength, and radiate with great violence from the point z. This spontaneous action continues often for a long while. If the negative pole be made to act in succession, opposite to two points z, z', of the mercury, and be then quickly withdrawn and the circuit broken, both these points become centres, from which spontaneous currents radiate simultaneously in all directions. If the negative pole be made to act vertically over a large flat surface, when the circuit is broken, a violent spontaneous radiation emanates from the point immediately below the place where it was situated.

46. If the wires be only withdrawn so as to complete the circuit in the liquid, the film formed during the contact of the positive pole is swept to the point c, opposite that pole; and a violent current is established, radiating from z to c. If this be suffered to continue some time, and the circuit be then broken, the motion continues as if the electricity still passed; but if the mercury be agitated, so as to break the crust collected at c, the regularity of the motion is disturbed: the surface of the mercury is thrown into a kind of filtration, owing to an immense number of minute and very rapid vortices; and it is not till after some time that a regular and uniform direction of the currents is re-established.

47. These phenomena demonstrate the existence of a system of currents radiating *towards* every molecule of the crust on the surface. In consequence of this, so long as the latter is broken up into small portions and distributed over the whole surface, the currents are irregular and undecided; but as soon as these portions begin to be swept together and collected, they assume a uniform direction, viz. towards that part where, from contact of the vessel or other cause, they meet with no counter currents to oppose them. In what manner the crust acts is however still

a little obscure: in all probability it forms a Voltaic combination with the mercury and the liquid.

48. In reasoning upon the facts detailed in this Paper, we have to consider, as probably materially influencing the results, first, the vast difference of conducting power between the metallic bodies set in motion, and the liquid under which they are immersed. This is not unlikely to enter as one of the essential conditions of the phænomenon, especially as it appears to result from all the experiments, that the peculiar action, whatever it be, by which the currents are produced, is exerted only at the common surface of the fluids. I have never been able to produce the least trace of such currents without the presence of a fluid metal. This leads us to conclude that a second essential condition is a perfect immiscibility of the conducting fluids, so as to render the transition from one to the other quite sudden. Besides these, a third essential condition is to be found in a certain chemical, or electrical relation between them. Under these conditions, it is by no means impossible, that the phænomena may admit of complete explanation from what we already know of the passage of electricity through conductors, and the high attractive and repulsive powers of the positive and negative electricities *inter se*. It is very possible, for instance, that a highly electro-positive body, as potassium, present in the mercury, may have its natural electric state exalted by its vicinity to the positive pole; and, being thus repelled, may take the only course the resistance of the metal on the one hand, and attraction of cohesion on the other, will permit; viz. along the surface, to recede from the positive pole. It *may* even act as a carrier of positive electricity, which *may* adhere to it too strongly to be transmitted through the mercury (which, though a good, is far from a perfect conductor;) and when arrived at the opposite side of the globule, may there, by the influence of the opposite pole, lose its exalted electrical state. This explanation tallies with that of other phænomena which have been attributed to a similar cause; I mean the tendencies observed in the vapours of electro-positive and electro-negative bodies to conductors electrified oppositely, which Mr. Brande has described in a Bakerian Lecture formerly read to this Society. Yet it must not be concealed that this explanation is beset with difficulties, and that the mode of action of the less-conducting medium in it is far from clear; it does not even appear why such a medium is at all necessary, unless we conceive it to retard, or otherwise modify the electric current, in its passage through it, and dispose it thereby to ready combination with the metallic molecules.

49. Another course is doubtless open to us, which is to consider the action which takes place at the common surface of two unequally conducting media, as one, *sui generis*, and to depend

on a new power of the electric current of a nature, bearing some analogy to the magnetic action, or possibly resulting from it; but this in the present state of our investigation would be too bold an hypothesis, especially as it is also a very vague one.

50. But whatever conclusions we may form, the phænomena are certainly interesting, and promise to afford abundant matter for future research. Meanwhile, it is not improbable that many phænomena of minute intestine motions usually attributed to capillary attraction, generation of heat, or other causes, may be referrible to similar causes. One I cannot forbear to mention, from the striking *external* resemblance of the effect to some of those described in this Paper. I mean the motions described by M. Amici in the sap of the chara, as originating in certain rows of globules disposed in the direction of the stream. The motion of the fluid in the vicinity of these globules has been attributed by M. Amici himself to electricity developed in some unknown manner by them, and is so similar to what takes place when a stream of electricity is made to pass over a row of minute globules of mercury under a conducting medium, that one has difficulty not to presume an analogy in the causes.

Slough, Jan. 6, 1824. J. F. W. Herschel.

NOTE.

51. Since writing the above, Mr. Faraday has been so good as to show me a Paper, published by M. Serrulas, in the Journal de Physique for 1821 (vol. 93), in which are related one or two of the appearances described in this Lecture, and other very curious ones referrible to the same causes (though not apparently regarded by him as being so). As the phænomena themselves are interesting, and the theory of them adopted by him is (as I shall easily show) insufficient, I shall be pardoned for extracting the whole passage from his Memoir; regretting at the same time not having been able to find a former Paper on the subject, mentioned by him, in which his explanation is given at full length.

52. The phænomena in question relate to the singular gyratory motions assumed by alloys of potassium when floated in small fragments on mercury under water. After noticing those of the alloy of bismuth, which he describes as particularly forcible and lasting, he goes on to say,

53. "Ne seroit-il pas intéressant d'étudier l'action électrique qui se manifeste dans cette circonstance pendant l'oxidation du potassium."—"Elle me semble digne d'attention pour sa liaison avec la décomposition de l'eau dont elle depend uniquement. * * * *

54. "La pellicule légère qui se forme dans ce cas n'est que le bismuth divisé provenant de l'alliage retenant entre ses mole-

cules des bulles d'hydrogène extrêmement fines. Cette pellicule, comme je l'ai dit, est attirée avec une grand promptitude par les substances métalliques mises en contact avec le mercure sur léquel les fragmens d'alliage sont en mouvement.

55. " J'ai du considérer cette pellicule comme jouissant de l'électricité positive, attendu qu'elle se porte vivement vers l'extrémité negative d'une cuve en activité, et qu'elle est au contraire puissamment repoussée par le pole positif. Si les deux conducteurs touchent seulement l'eau du bain, l'attraction et la repulsion ont lieu dans le sens indiqué. L'effet est encore le même si l'un des fils touche le mercure, et l'autre l'eau. La pellicule se fixe au pole negatif d'où elle est chassé avec force par l'approche du pole opposé. Elle s'écarte, et l'hydrogène de l'eau décomposée se dégage sur ses bords qui dans ce cas font partie du conducteur et le terminent. Si les deux fils plongent dans le mercure il est bien entendu qu'il ne se manifeste plus rien.

56. " Quand, au lieu d'eau simple, le bain de mercure est couvert d'une dissolution peu chargée du chlorure de sodium, le tournoiement des fragmens est plus lent. L'hydrogène produit se trouve engagé et retenu presqu'entièrement par la pellicule du bismuth; l'eau en devient nebuleuse. A l'instant où l'on a plongé dans le bain une tige métallique, on remarque autour de celle-ci un frémissement; les mouvemens cessent et sont arrêtés tant que la tige rest plongée ; elle fixe la pellicule dans toute l'étendue du bain ; les fragmens d'alliage y sont emprisonnés ; mais aussitot que la tige est retirée, *l'effluve d'hydrogène écarte la pellicule, et les mouvemens recommencent.*

57. " Un fil plongé sur un point quelconque d'un bain ou tournoie l'alliage, même dans un endroit éloigné de ce tournoiement, la partie plongée de ce fil se couvre en peu de temps d'une multitude des bulles d'hydrogène. Ne pourroit-on pas encore d'après cette observation, *qui prouve que toute la surface du bain est parcourue d'hydrogène,* ne pourroit-on pas trouver dans l'émission rapide et abondante de ce gas la cause de l'électricité, quand on considère que l'air atmosphérique dirigé avec une soufflet sur un carreau de verre donne à ce carreau l'électricité vitrée ; ou bien cette effluve d'hydrogène qui pousse vivement sur le mercure les molecules de bismuth non amalgamé, qui les réunit sous forme de pellicule, produit entre les deux métaux un frottement qui développe cette électricité."

58. From these passages it seems natural to collect, that M. Serrulas conceives, 1st, the production, motion, &c. of the pellicle on the surface to originate in the actual mechanical impulse of streams of hydrogenous matter (*effluve d'hydrogene*), radiated in all directions from the potassium in the moment of its oxidation. That, 2ndly, this bodily radiation of hydrogen is propagated along the surface to any distance. That, 3rdly,

the hydrogen disengaged in bubbles from a metallic wire plunged into the mercury is this actual radiant hydrogen, conveyed and collected on its surface from all parts of the mercury. That, 4thly, the friction of the hydrogen so radiated produces the electricity, and not the electricity the hydrogen. And, lastly, that the gyration of the fragments themselves is a consequence of the re-action of the hydrogen they dart out during their oxidation by the water.

59. All these phænomena, however, are much better accounted for on the principles of this Lecture, from a knowledge of the properties conferred on mercury by alloying it with potassium; but, first, it is necessary to premise, that the mere contact of a metal capable of amalgamating, even for an instant, communicates its peculiar properties, almost in the moment of contact, to the whole mass. The experiments in Art. 33, abundantly prove this; and it may be readily shown also by the following. Let a quantity of mercury be placed in a vessel of muriatic acid; no action takes place; but if touched with a zinc wire it presently becomes covered with bubbles, copiously disengaged from every part of the surface.

60. In the circumstances of M. Serrulas's experiments, it is therefore obvious that his mercury must have been always sensibly impregnated with potassium and the supernatant liquid, a solution of potash; and that it was so, is proved by the effects of the electric current, which agree precisely with those I have stated, as being always produced in such circumstances (Articles 18, 28); but the cause assigned to these effects by Mr. S. viz. the electro-positive energy *of the pellicle*, is proved not to be the real one by the simple fact, that the violence of the motion is always proportional to the cleanliness of the surface, and is greatest when there is no pellicle at all; besides which the pellicle *here* consisted of metallic bismuth, a substance incapable of producing any such effect as shown in Art. 38.

61. The gyration of the fragments is produced as follows: a strong Voltaic excitement takes place at the point of contact of two metals so different as mercury and potassium. The mercury becomes strongly positive, and the floating fragments negative. The circuit is completed by the alkaline liquid; and the mercury, being alloyed with a portion of potassium, and being itself the positive pole of the combination, we have here the case of Art. 21; and the result, as stated by M. Serrulas, is precisely as in that experiment, the currents radiating from the point of immersion. These once produced, drive before them the fragment in which they originate, in the direction in which it exposes the greatest surface to their action.

62. The attraction of the pellicle to a metallic rod plunged into the mercury is also a direct consequence of the alloy of potassium present in the mercury, as is also the disengagement

of gas from the wire. It is, in fact, precisely the experiment described in Art. 25, and has nothing whatever to do either with the floating fragments, or with any hydrogen they may be discharging at the time, farther than that their contact serves to furnish potassium to the mercury.

63. It is needless, therefore, to push this examination further, as all the phænomena observed by Mr. S. are only particular cases of those I have described. With regard to the radiant hydrogen producing currents by its impulse, I would ask how it happens that currents are produced (when the positive pole is placed in contact), while a thick and tough coat of oxide covers the whole surface; and, one would think, must effectually defend it from the action of the hydrogen. Yet we have seen, in Art. 18, that the currents continue their course under this crust; and it will hardly be contended, that the hydrogen finds a passage between the oxide and the metal.

London, Jan. 13, 1824. J. F. W. H.

Article XII.

Nitric Ether. By Mr. Whipple.

(To the Editors of the *Annals of Philosophy*.)

GENTLEMEN, *Elaboratory, London, Sept.* 17, 1824.

Since to give my opinion on the directions given by Dr. Ure in his Chemical Dictionary, for conducting a retort distillation of nitric ether, would be γλαυκα εις Αθηνας κομιζειν, I shall feel obliged if favoured with an insertion of the following question:

Whether the directions for the management of a glass retort in forming nitric ether, be correctly stated in Dr. Ure's Chemical Dictionary?

I remain, Gentlemen, your most obedient servant,

G. Whipple.

Article XIII.

Astronomical Observations, 1824.
By Col. Beaufoy, FRS.

Bushey Heath, near Stanmore.

Latitude 51° 37′ 44·3″ North. Longitude West in time 1′ 20·93″.

Occultations of stars by the moon.

Sept. 4. Immersion of a small star.....	19ʰ	10′	54·0″	}	Siderial Time.
Sept. 15. Immersion of a small star.....	3	28	46·2″	}	

Article XIV.

Remarks on Solar Light and Heat. By B. Powell, MA. FRS.

(46.) I concluded a former portion of these inquiries with some remarks on the small development of a heating effect which is observable exterior to the cone of light formed by a lens. The investigation of its nature appearing to me a topic of considerable interest as bearing upon many other parts of the science of light and heat, I have been led to try several experiments upon the subject. The results of these trials in which the circumstances and conditions of the case have been varied in several different ways, I here propose to give in a tabular form, and to introduce them by a few remarks on the nature and object of the experiments, as well as on the sort of conclusion, which can safely be deduced from them.

(47.) The existence of the effect in question being admitted, two suppositions obviously present themselves as to its nature. It may be attributed to certain rays of light refracted to a position beyond the principal body of rays which go to form the focus. These may be rendered invisible or nearly so from the proximity of other rays of infinitely superior intensity. And thus the phenomenon may be nothing more than simply the ordinary heating effect of these rays displayed on the black bulb of the instrument. Again, it may be supposed (which seems to have been the idea of the first observer of this and kindred phenomena), that it is owing to some sort of radiant heat. From his analogical view of the subject, it would have followed that these were rays of a peculiar kind different from those of terrestrial heat, and exhibited as existing in a separate state from the rest of the solar rays by the refractive powers of the lens ; rays in fact of a sort of intermediate character between light and common heat. If, however, because we cannot *see* the rays producing this effect we should think it necessary to infer that they must be rays of simple heat, or if we had any better experimental reasons for such a conclusion, still it would not, I conceive, be at all necessary to suppose any thing peculiar in their nature, or that they were really an emanation entirely *sui generis ;* for there would still be no proof whatever that they had passed through the thick glass of the lens in the form of rays of simple heat. It is obvious that we may, in all respects, as well suppose them to have originated, or have been separated in some way from the deflected rays of light after their passage through the lens ; and it would seem that such a supposition is the more incumbent on us, when we admit what has, I conceive,

been above sufficiently proved, the non-existence of any rays of heat (at least in a free and separate state) in the solar beam.

(48.) It is obvious that by several different applications of the differential thermometer, we may examine the validity of such views, and decisively ascertain whether this heating power is of such a nature as to affect the bulb of black glass alone, or also to produce some effect on the plain one, which is equally absorptive for simple heat. With this view several of the following experiments were tried. In Experiments, Nos. 1, 2, and 3, I observed the effect which would arise when each of the bulbs was respectively placed just without the rays, as compared with the indication when they were both equally exposed, by having the focus thrown between them (they being at nearly 0·75 inch distance), and when both away from the rays at an equal distance under the shadow of an opaque screen which surrounded the lens on all sides. In this disposition of things, it is evident that if the effect were due to simple radiant heat, the indication when the focus was between the bulbs, should not differ from that displayed when they were at a distance. Again the effect when the plain bulb was nearest should have been as much below the point at which the instrument stood when away, as the effect with the black bulb nearest was above it.

(49.) The first of these conditions took place only in Exp. 3; a difference is perceptible in 1, 2, 4, 5, 6, and 7.

The second is observed in some degree in Nos. 4, 6, 7, though not to the extent which the supposition would require; it is, however, completely shown in No. 12. An effect on the plain bulb is shown in Nos. 1, 2, and 6, as well as subsequently in No. 16. The effect also when the focus was between the bulbs is in general greater than on the black bulb when the other was at a greater distance.

Thus far then we can only conclude, that though simple heat may be in action, it is not the sole cause of the effect: light unquestionably contributes to it. The aperture of the lens was varied in the two sets of experiments. This does not seem to have at all altered the effect, yet it must have altered any effect which was immediately dependent on the convergence of the rays.

From some other trials I was convinced that the light of the focus reflected in different ways from the inner surface of the glass case affected the results. Hence Exp. 6 and 7 were tried without the case; but the effects were still nearly the same relatively to each other, the total intensity of each being of course diminished.

(50.) In prosecuting the inquiry, my next idea was to present a surface absorptive for simple heat, but only covering the bulb in part in order that the increased radiation might not counter-

balance the effect. This was done in Exp. 8, 9, and 10, upon the bulb before plain, by attaching to it a small piece of light-brown silk. In these a decided action was produced on this bulb; whilst an equal one in the contrary direction was displayed by the smooth black surface; but this might be occasioned by the greater power of absorbing light now acquired by the bulb before transparent. In the next experiment, therefore (No. 11), I attached a similar piece of silk to the black bulb; the effect, if merely due to light, ought by this means to have been considerably diminished; but it is evident on inspection that it was quite equal to that on the plain black surface. Some additional effect of simple heat must, therefore, have made up for the diminution which must have been occasioned by the decreased absorption of light.

Exp. 12 was tried immediately after No. 11, and shows more decidedly that the alteration of the aperture makes no difference in the effect. It would seem then (since with a diminished aperture the total number of rays is less), to *increase* with the more accurate convergence, instead of being diminished, as it would be if owing to the straggling rays of light, or to less refrangible rays of heat.

(51.) According to the view of the phenomena before adverted to, an exterior and invisible heat accompanying the concentration of light by a lens was considered as analogous to the separation of peculiar invisible heating rays beyond the red end of the prismatic spectrum. It would, however, admit of considerable question, whether the distance from the rays at which the former effect is perceptible is not much greater compared with space occupied by the coloured edges of the section of the cone, than would be at all proportional to the distance of the exterior heat in the other case beyond the visible boundary of the red rays. If, again, according to the experimental authority on which both facts were originally brought forward, the exterior effect in the one case is the maximum, ought there not to be some analogous result in the other? It might, perhaps, from the difference of circumstances, be impossible to ascertain this satisfactorily; but if only the smallest portion of the exterior red fringe of the cone be made to glance upon the surface of the bulb, the effect is enormous compared with the greatest indication while any sensible space intervenes between the bulb and the light. These considerations led me to the idea of comparing the exterior effect with a common simple lens, and a compound achromatic one of the same aperture. This would show whether it were owing to any thing connected with the dispersion or different refrangibility of the coloured rays; if so, the effect with an achromatic lens would be altogether or nearly imperceptible. The lenses I employed were a small achromatic one made by Dolland, of about one inch aperture, and 7·5 focal

length: this was compared with a simple lens of about the same focal length, having its aperture diminished by a diaphragm to the same size, and at its central part about the same thickness as the compound one. The results of this comparison are given in Exper. 13 and 14; and it is there, I conceive, quite clear, that the exterior effect *is as nearly as possible equal in both cases.* Hence, I think, I am warranted in concluding, to whatever sort of rays the phenomena is owing, the principal part of them at least are not of the same kind, or subject to the same affections and modifications, as those refracted by the lenses.

(52.) Having by me a smaller instrument of the same kind, I thought it worth while, for the sake of comparison, to make a few observations with it. This instrument is of the "portable" description, having its plain bulb in a line under the other. The apparently less indications in Exp. 15 and 16 arise only from the two instruments not being adjusted to the same point as the zero. In these results, as I before observed, the action on the plain bulb is, perhaps, more conspicuous than in any former instances.

(53.) I was extremely desirous of trying the relations of this heating power to transparency in screens. This, in some measure, might have been ascertained by means of the small instrument when in its glass case as compared with the effect when the case was removed; but I have not given any of these results, as I found it extremely difficult to pass the rays into the small cylindrical case of this instrument without producing reflections from its inner surface which totally interfered with the results. In some instances, as in No. 16 compared with No. 15, the effect on the blackened bulb was as great without the case as with it. This seems to be in favour of the non-transmissibility of the effect through glass, because, in the absence of the case, it ought to have been very considerably less. To attempt the application of plates of glass as screens in cases of so delicate a nature, and when the screen must almost touch the bulb, appeared quite impracticable on account of the cooling effect of the glass. In this respect I must be content to leave the investigation imperfect. It is, however, most probable, that with large and powerful lenses the effect might be sufficiently great to admit of some application of this kind. As well in respect to this point as to others, I am willing to confess the imperfections of the present inquiry. I take this opportunity, therefore, of saying, that I should feel the greatest interest in hearing that a similar train of investigation had been carried on by those who may be possessed of large lenses, or may be able to devise more accurate and satisfactory methods of operating.

(54.) From this series of experiments, in its present state I shall not attempt to draw any general or theoretical inferences, but shall content myself with remarking, that so far as these

results are thought sufficient, they may be considered as countenancing the idea that the effects in question, though they may be partly owing to rays of light either refracted beyond the main body of the rays, or even of a more adventitious character, are yet also, in part at least, owing to some radiation of simple heat which seems to accompany the luminous rays in their course, and to extend to a short distance from them, so as to form a sort of exterior conical surface to that formed by the rays of light. This we seem to recognise in the greater effect produced on the more absorptive coating; but as to the characteristic of its being capable or not of permeating glass, we can infer nothing decisively. I have already observed that we cannot at all assume that any such rays passed through the lens in their present state. We should, therefore, by analogy, be rather inclined to the supposition that they take their origin in some way from the circumstance of the concentration of the luminous rays; as from the experiment with the achromatic lens it seems altogether disproved that the dispersion of coloured rays at the edge can be connected with this phenomenon.

(55.) I now proceed to the details of the experiments; and before giving those above referred to, I may be permitted to mention a few which I tried at an earlier period.

A first trial was performed with a common thermometer; it was, in the first instance, coated with Indian ink; afterwards the paint was thickened with powdered charcoal. The following are the results:—

Centigrade degrees risen in one minute.	Indian ink.	Ditto with powdered charcoal.	
		Exp. 1.	Exp. 2.
¼ inch outside of luminous cone.....	1·5°	3°	2·5°
Away from the rays. Under the shadow of the lens.....	1°	1·5°	1°

The following are also some results which I formerly obtained with a differential thermometer; the coating of black silk did not completely cover the bulb. The indications differ from the subsequent experiments owing to the liquor being differently adjusted.

Bulb coated with black silk.	
¼ inch outside	10°
½ inch	8
¾ inch	7
1 inch, and nearer lens	5

Bulb painted with Indian ink.	
¼ inch	5°
1 inch, near lens	3

(56.) I now proceed to the later series of experiments :—

Lens, focal distance 7·5 inches. Aperture reduced to 1 inch. Distance from lens 7·5 inches. Bulb just without the cone of rays.

Exp.	Focus thrown between the bulbs.	Both bulbs away, and under shadow.	Black bulb nearest the rays.	Plain bulb nearest.
1	53 52	50	49 50	46 45
2	52	45 46	44 45	41 42
3	44 45	44	47	44
		Aperture 3·5 inches.		
4	48	43 44	48 47	43 42
5	50	45	51	45
		No case.		
6	45 44	35 34	42	32 33
7	44	31 33	38 37	31 32

No case. Aperture 3·5 inch.

	Both bulbs away.	Black nearest.	Other bulb nearest. In part coated with brown silk.
8	25	27	22
9	26	27	20 17
10	30	31 30	18

In case.

	Both bulbs away.	Black bulb nearest.	Black, partly coated with brown silk.
11	37 35	39 40 41	40 42

Aperture 1 inch.

	Both bulbs away.	Black bulb nearest.	Plain bulb nearest.
12	36 34	39 40 38	32

Simple lens. Aperture 1 inch. Focal distance 7·5 inch.

Exp.	Bulb.	Distance from rays.	Indication.
13	Black bulb nearest.	Just without.	49 47 48
		Inch. 0·25	48 47
	Opposite focus.	Inch. 1·5	37 38

Achromatic lens. Aperture 1 inch. Focus distance 7·5 inches.

14	Ditto.	Just without.	50
		Inch 0·25	48 45
		Inch 1·5	40 39
		Away, but under shadow	38

Small instrument. Bulb painted with Indian ink.

		In case.	No case.
15	Just without the focus.	10 12	7
	Away under shadow.	4	3

No case.

	Away.	Focus near black bulb.	Focus near plain bulb.
16	2 3	9 10	4

It was with this instrument that the experiments in the former paper were made. (*Annals*, Aug. Art. 1, § 44.)*

In conclusion I will merely say, that still admitting a considerable degree of uncertainty to hang over this subject, I shall endeavour to prosecute the further examination of it whenever it may be in my power to vary and extend the experiments. Meanwhile I beg to repeat my request to those who have lenses of large size to examine the phenomena which they present. A delicate common thermometer would be amply sufficient to display the effects; and my hope that some experimenter may be thus induced to take up the subject, and to extend it also to the case of concentration of light by reflection, has been my chief motive for publishing these experiments under their present imperfections.

* In the experiments referred to, an error has crept in which I wish to correct. *For* "$\frac{1}{2}$ inch without the rays," *read* $\frac{1}{4}$ inch.

Article XV.

On Semi-decussation of the Optic Nerves. By William Hyde Wollaston, MD. VPRS.*

Whether we consider the astonishing subtlety of that medium, which renders visible to us objects existing at the most immeasurable distances from us, or that delicately constituted organ which, by its general structure, collects the rays of light, and by a nice adaptation of its parts concentrates their force on the sentient fibres of the retina, expanded over its inner surface, we can feel no surprise that such great talents should have been devoted to investigate the curious properties of the one, or that the structure of the other should have been examined with so much assiduity.

The keenness of inquiry manifested by the cultivators of anatomy in observing the most minute parts that have escaped the notice of their predecessors, shows that any addition to the common stock of our information on this subject will be gratifying to a certain portion of the members of this Society, and probably not uninteresting to the Society at large.

It is not my object, in the present paper, to examine either the *first* effect of the cornea in rendering the rays of light convergent, or the power of the crystalline lens in *finally* bringing them to a focus on the retina. It is not my intention to investigate whether the adaptation of the eye to different distances is effected by alteration of the *form* of the lens from its own muscular structure, or by alteration of its *place*, from the agency of other muscles. Nor do I mean to consider either the *involuntary* motions of the iris dependent on the quantity of light present, or that *voluntary* contraction of it by which we adapt the aperture of the pupil for distinct vision at different distances, limiting thereby, what in optics is termed the spherical aberration of the lens.

The subject of my inquiry relates solely to the course by which impressions from images perfectly formed are conveyed to the sensorium, and to that structure and distribution of the optic nerves on which the communication of these impressions depends.

Without pretending to detect by manual dexterity as an anatomist, the very delicate conformation of the nerves of vision, I have been led, by the casual observation of a few instances of diseased vision, to draw some inferences respecting the texture of that part which has been called the decussation of the optic nerves, upon which I feel myself warranted to speak with some confidence.

* From the Philosophical Transactions for 1824, Part I.

It is well known that in the human brain these nerves, after passing forwards to a short distance from their origin in the thalami nervorum opticorum, unite together, and are, to appearance, completely incorporated; and that from this point of union proceed two nerves, one to the right, the other to the left eye.

The term decussation was applied to this united portion under the supposition that, though the fibres do intermix, they still continue onward in their original direction, and that those from the right side cross over wholly to supply the left eye, while the right eye is supplied entirely from fibres arising from the left thalamus.

In this opinion, anatomists have felt themselves confirmed by the result of their examination of other animals, and especially that of several species of fish, in which it is distinctly seen that the nerves do actually cross each other as a pair of separate cords, lying in contact at their crossing, but without any intermixture of their fibres.

In these cases it is most indisputably true, that the eye upon the right side of the animal does receive its optic nerve from the left side of the brain, while that of the left eye comes from the right side; but it is not a just inference to suppose the same continuity preserved in other animals, where such complete separation of the entire nerves is not found.

On the contrary, I not only see reason, from a species of blindness which has happened to myself more than once, to conclude, that a different distribution of nerves takes place in us, but I think my opinion supported by this evident difference of structure in fishes.

It is now more than twenty years since I was first affected with the peculiar state of vision, to which I allude, in consequence of violent exercise I had taken for two or three hours before. I suddenly found that I could see but half the face of a man whom I met; and it was the same with respect to every object I looked at. In attempting to read the name JOHNSON, over a door, I saw only SON; the commencement of the name being wholly obliterated to my view. In this instance the loss of sight was toward my left, and was the same whether I looked with the right eye or the left. This blindness was not so complete as to amount to absolute blackness, but was a shaded darkness without definite outline. The complaint was of short duration, and in about a quarter of an hour might be said to be wholly gone, having receded with a gradual motion from the centre of vision obliquely upwards toward the left.

Since this defect arose from over fatigue, a cause common to many other nervous affections, I saw no reason to apprehend any return of it, and it passed away without need of remedy, without any farther explanation, and without my drawing any useful inference from it.

It is now about fifteen months since a similar affection occurred again to myself, without my being able to assign any cause whatever, or to connect it with any previous or subsequent indisposition. The blindness was first observed, as before, in looking at the face of a person I met, whose *left* eye was to my sight obliterated. My blindness was in this instance the reverse of the former, being to *my right* (instead of the left) of the spot to which my eyes were directed; so that I have no reason to suppose it in any manner connected with the former affection.

The new punctum cæcum was situated alike in both eyes, and at an angle of about three degrees from the centre; for when any object was viewed at the distance of about five yards, the point not seen was about ten inches distant from the point actually looked at.

On this occasion the affection, after having lasted with little alteration for about twenty minutes, was removed suddenly and entirely by the excitement of agreeable news respecting the safe arrival of a friend from a very hazardous enterprise.

In reflecting upon this subject, a certain arrangement of the optic nerves has suggested itself to me, which appears to afford a very probable interpretation of a set of facts, which are not consistent with the generally received hypothesis of the decussation of the optic nerves.

Since the corresponding points of the two eyes sympathise in disease, their sympathy is evidently from structure, not from mere habit of feeling together, as might be inferred, if reference were had to the reception of ordinary impressions alone. Any two corresponding points must be supplied with a pair of filaments from the same nerve, and the seat of a disease in which similar parts of both eyes are affected, must be considered as situated at a distance from the eyes at some place in the course of the nerves where these filaments are still united, and probably in one or the other thalamus nervorum opticorum.

It is plain that the cord, which comes finally to either eye under the name of optic nerve, must be regarded as consisting of two portions, one half from the right thalamus, and the other from the left thalamus nervorum opticorum.

According to this supposition, decussation will take place only between the adjacent halves of the two nerves. That portion of nerve which proceeds from the right thalamus to the right side of the right eye, passes to its destination without interference; and in a similar manner the left thalamus will supply the left side of the left eye with one part of its fibres, while the remaining halves of both nerves in passing over to the eyes of the opposite sides must intersect each other, either with or without intermixture of their fibres.

Now, if we consider rightly the facts discovered by comparative anatomy in fishes, we shall find that the crossing of the

entire nerves in them to the opposite eyes, is in perfect conformity to this view of the arrangement of the human optic nerves. The relative position of the eyes to each other in the sturgeon, is so exactly back to back, on opposite sides of the head, that they can hardly see the same object; they can have no points which generally receive the same impressions as in us; there are no corresponding points of vision requiring to be supplied with fibres from the same nerve. The eye which sees to the left has its retina solely upon its right side; and this is supplied with an optic nerve arising wholly from the right thalamus; while the left thalamus sends its fibres entirely to the left side of the right eye for the perception of objects situated on the right. In this animal, an injury to the left thalamus might be expected to occasion entire blindness of the right eye alone, and want of perception of objects placed on that side. In ourselves, a similar injury to the left thalamus would occasion blindness (as before) to all objects situated to our right, owing to insensibility of the left half of the retina of both eyes.

A disorder that has occurred within my own knowledge in the case of a friend, seems fully to confirm this reasoning, as far as a single instance can be depended upon. After he had suffered severe pain in his head for some days, about the left temple, and toward the back of the left eye, his vision became considerably impaired, attended with other symptoms indicating a slight compression on the brain.

It was not till after the lapse of three or four weeks that I saw him, and found that, in addition to other affections which need not here be enumerated, he laboured under a defect of sight similar to those which had happened to myself, but more extensive, and it has unfortunately been far more permanent. In this case the blindness was at that time, and still is, entire, with reference to all objects situated to the right of his centre of view. Fortunately, the field of his vision is sufficient for writing perfectly. He sees what he writes, and the pen with which he writes, but not the hand that moves the pen. This affection is, as far as can be observed, the same in both eyes, and consists in an insensibility of the retina on the left side of each eye. It seems most probable, that some effusion took place at the time of the original pain on that side of the head, and has left a permanent compression on the left thalamus. This partial blindness has now lasted so long without sensible amendment, as to make it very doubtful when my friend may recover the complete perception of objects on that side of him.

In reviewing the several phænomena that I have described, we find partial blindness occurring at the same time in both eyes. This sympathy from disease is readily explained, on the supposition that the parts which sympathise receive their nerves from the same source, while the opposite halves of the eyes, which

are not at the same time similarly affected, are supplied from an opposite source; and the inference is immediate, that in common vision also the sympathy of corresponding points, which receive similar impressions from the same object, is dependent on the arrangement of nerves thus detected by disease.

We find moreover in the sturgeon (and it is the same in some other fishes), whose eyes can scarcely see the same object at once, and have no corresponding points which ordinarily sympathise, that the two eyes do not receive any nervous fibres from the same source; but one eye receives its nerve wholly from one side, and the other from the other side of the brain.

From the structure of these fish we learn distinctly, that the perception of objects toward one side is dependent on nerves derived from the opposite side of the brain; and in the last case of diseased vision above related, we find apparent injury to one side of the brain, followed by blindness toward the opposite side of the point to which both eyes are directed.

A series of evidence in such apparent harmony throughout, seems clearly to establish that distribution of nerves I have endeavoured to describe, which may be called the semi-decussation of the optic nerves.

On Single Vision with Two Eyes.

So long as our consideration of the functions of a pair of eyes is confined to the performance of healthy eyes in common vision, when we remark that only one impression is made upon the mind, though two images are formed at the same moment on corresponding parts of our two eyes, we may rest satisfied in ascribing the apparent unity of the impression to habitual sympathy of the parts, without endeavouring to trace farther the origin of that sympathy, or the reason why, in infancy, the eyes ever assume one certain direction of correspondence in preference to squinting.

But, when we regard sympathy as arising from structure, and dependent on connexion of nervous fibres, we therein see a distinct origin of that habit, and have presented to us a manifest cause why infants first begin to give the corresponding direction to their eyes, and we clearly gain a step in the solution, if not a full explanation, of the long agitated question of single vision with two eyes.

It may perhaps to some persons appear surprising, that so many as three instances of a disorder which they presume to be rare, should have been witnessed by one individual; but I apprehend, on the contrary, this half-blindness to be far more common than is generally supposed; and I might with as much

reason express surprise at its having so far escaped notice,* were I not aware how many facts commonly remain disregarded, merely for want of explanation. It is evident that I once, and for a long time, overlooked the inference that is to be drawn from this affection; and if the disorder had not happened to me a second time, I might never have reconsidered its cause.

Even since the preceding pages were written, I have met with two more cases of this disease. One of my friends has been habitually subject to it for 16 or 17 years, whenever his stomach is in any considerable degree deranged. In him the blindness has been invariably to his right of the centre of vision, and, from want of due consideration, had been considered as temporary insensibility of the right eye; but he is now satisfied that this is not really the case, but that both eyes have been similarly affected with half-blindness. This symptom of his indigestion usually lasts about a quarter of an hour or twenty minutes, and then subsides, without leaving any permanent imperfection of sight.

I have not seen the subject of the 5th case, but I am informed that he has had many returns of this affection, generally attended with head-ach, and always lasting about 20 minutes, with very little variation.

Article XVI.

Experiments on the Analysis of some of the Aëriform Compounds of Nitrogen. By William Henry, MD. FRS. &c. &c.† (Communicated by the Author.)

1. *The Analysis of Nitrous Oxide and Nitrous Gas.*

The methods of analyzing nitrous oxide and nitrous gas, described in the following pages, derive any value they may possess, from their enabling us to demonstrate the composition of those gases, by processes which admit of being more quickly executed than the methods already in use, and which, at the same time, are capable of affording results approaching as nearly to perfect accuracy, as is consistent with the nature of such investigations. The decomposition of nitrous oxide may, indeed, be readily and expeditiously effected, in consequence of its forming a combustible mixture with hydrogen gas,

* Richter, in the third volume of his Elements of Surgery, has a chapter on half-blindness, and part of it relates to what he terms amaurosis dimidiata. From one instance there given, he seems to have seen some cases similar to those I have described; but he has not noticed the corresponding affection of the two eyes, or considered the sympathy between them.—(Anfangs-gründe Der Wundartzeneykunst, vol. iii. chap. 16, p. 478.)

† From Vol. IV, New Series, of Memoirs of the Literary and Philosophical Society of Manchester.

a property discovered by Dr. Priestley, but first applied to the purpose of its analysis by Sir H. Davy, in the course of his researches into the compounds of nitrogen.* In the experiments of that philosopher, the results, approaching most nearly to precision, were obtained by detonating nitrous oxide with rather more than an equal volume of hydrogen, viz. 39 measures of the former to 40 of the latter. Both gases were in this case decomposed; water was produced; no nitrous acid was formed; and a volume of nitrogen remained, which always a little exceeded that of the nitrous oxide decomposed, viz. in the proportion of about 41 to 39.

In the repetitions which I have frequently made of this experiment, a similar excess of the accruing nitrogen, over the volume of the nitrous oxide employed, has always been observed, and generally in about the same proportion. But according to the law regulating the combination of gaseous bodies with each other, which has been deduced by M. Gay Lussac from a great variety of examples,† all tending to show, that gases unite in proportions as to volume, which are either equal, or simple multiples of each other, nitrous oxide ought to be constituted of *exactly* one volume of nitrogen and half a volume of oxygen condensed into the space of one volume; and those products should result from every careful decomposition of the gas in question. That they are not correctly obtained by the method which I have just alluded to, appears to be owing to sources of inaccuracy, necessarily connected with that mode of analysis. I was induced, therefore, to try various other processes, among which there is one that may deserve to be made known, since it exhibits, in a very summary way, and by a single operation, the quantities of nitrogen and oxygen that enter into the constitution of nitrous oxide, with as much precision as, I believe, is attainable in the present state of gaseous analysis. This method consists in firing, by the electric spark, a mixture of nitrous oxide and carbonic oxide in due proportions. The nitrous oxide, which I employed, was obtained by the careful decomposition of nitrate of ammonia, and did not contain in 100 parts more than 3 parts of gas unabsorbable by well boiled water. The carbonic oxide was generated from recently ignited chalk and iron filings, and after having been washed with caustic potash, appeared, from the results of its combustion with oxygen, to be contaminated with not more than 3 per cent. of foreign gas, having the properties of nitrogen. Some nicety was found to be necessary in adjusting the proportions of the gases to each other, in order to obtain a perfect decomposition. When an excess of nitrous oxide

* Davy's Researches, London 1800, p. 286.
† Memoires de la Soc. d'Arcueil, ii. 207.

was used, some free oxygen was always detected in the residue; and yet a slight redundancy of nitrous oxide appeared to be essential to the perfect combustion of the carbonic oxide. After firing the mixed gases, and removing the carbonic acid by liquid potash, I next determined the proportion of oxygen in the residue by commonly known methods, and considered the remainder as nitrogen gas. An example, taken from an experiment made with great care, will best illustrate the nature of the process.

Carbonic oxide 25 measures = 24·25 pure + 0·75 azote.
Nitrous oxide 26 do. = 25·25 do. + 0·75 do.

51
52 after combustion.
28 after potash; found to consist of 0·85 oxygen + 27·15 nitrogen.

In this case, the carbonic acid, from 24·25 real carbonic oxide was 24 measures.

The nitrogen was by experiment 27·15

By calculation it ought to have been,

From the nitrous oxide 26
Do. carbonic oxide ·75 26·75

Difference 0·40

No person, I believe, who is much experienced in processes of this nature, will look for a nearer approach to accuracy, than in the results of the experiment which has been just described; for the carbonic acid falls short by only $\frac{1}{96}$ of the theoretical proportion; while the nitrogen exceeds that proportion by only $\frac{1}{68}$, and the oxygen by $\frac{1}{70}$. The experiment was several times repeated, with approximations fully as near as the above to those which the law of volumes would require.

When the object in view is solely or chiefly to determine the quantity of oxygen in nitrous oxide, there can be no source of fallacy in the use of a slight excess of carbonic oxide. For this purpose I made several experiments, which agreed so closely in their results, that it may be sufficient to particularize one of them as a specimen of the rest.

Carbonic oxide 21 measures.
Nitrous oxide 19 do. = 18·4 pure + 0·6 nitrogen.

40
40 after combustion.
21·5 after potash; containing no free oxygen.

In this case, the carbonic acid was $40 - 21{\cdot}5 = 18{\cdot}5$, and therefore exceeded in volume the theoretical proportion (18·4) by only $\frac{1}{185}$, a deviation much within the limits of possible errors, arising either from the difficulty of measuring small quantities, or of ascertaining the purity of nitrous oxide. We may, also, from this mode of operating, deduce the quantity of nitrogen, which exists as an element of nitrous oxide; for since 1 volume of carbonic acid results from the combustion of 1 volume of carbonic oxide, the residuary 21·5 measures must have contained $21 - 18{\cdot}5 = 2{\cdot}5$ of carbonic oxide and nitrogen introduced by that gas, + 19 measures of nitrogen disengaged from the nitrous oxide.

The results of the experiments with an excess of carbonic oxide suggested to me a ready and correct method of *testing* the nitrous oxide, which had hitherto been a desideratum. The only test, before applicable to this purpose, was the amount, to which the gas is absorbed, when agitated with well boiled water. But besides the uncertainty whether all the nitrous oxide be in this case condensed, the proportion of the unabsorbed residuum is subject to variation, from the quantity of other gases extricated from the water itself. Reduced to the form of a rule, the new method may be stated as follows: Let a given volume of nitrous oxide be exploded with a slight excess of carbonic oxide of known purity; for example, 110 or 115 measures of the latter to 100 of the former. Now as each volume of *real* nitrous oxide gives, under these circumstances, an equal volume of carbonic acid, we may impute whatever carbonic acid is deficient of that proportion to the mixture of so much nitrogen with the nitrous oxide. If, for example, using an excess of carbonic oxide, there should result, from 100 measures of nitrous oxide, only 95 of carbonic acid, we may safely consider the nitrous oxide to be contaminated with 5 per cent. of nitrogen gas. A proportion of nitrous gas may, I am aware, be occasionally mixed with the nitrous oxide, but this may be easily discovered, and previously separated, by solution of green sulphate of iron.

Having determined the application of carbonic oxide to the analysis of nitrous oxide to be so easy and satisfactory, I had hoped that the same agent might have been employed in the analysis of nitrous gas, which, as is well known, does not form a combustible mixture with simple hydrogen gas.* But on trial, I could not, by any variation which I made in the proportions of the two gases, obtain a mixture combustible by electricity. I had recourse, therefore, to olefiant gas; but had nearly abandoned this method also as impracticable, on finding that the mixture could not be set on fire by a spark from the prime

* Davy's Researches, p. 136.

conductor of an electrical machine. The discharge, however, of a small Leyden jar, through a mixture of nitrous gas and olefiant gas, occasioned a vivid combustion, and both gases were entirely decomposed. The following experiment may be taken as an example:

Olefiant gas 6·5
Nitrous gas 46·5 = 45·1 pure + 1·4 nitrogen.
53·0
40 fired.
27 washed with potash.

In this case 40 − 27 = 13 measures of carbonic acid were formed, which are just double the volume of the olefiant gas. In the residuary 27 measures, I found 2·7 measures of free oxygen. But 6·5 measures of olefiant gas require for saturation 19·5 of oxygen, to which, adding the residuary 2·7, we have 22·2 measures of oxygen by experiment in 45·1 nitrous gas; while theory would require 22·55 or about $\frac{1}{64}$ more than was actually obtained. Again, the residuary nitrogen was 27 − 2·7 = 24·3; while from theory it should have been half the volume of the pure nitrous gas, viz. 22·55 + the impurity of the latter 1·4 = 23·95. The actual proportion of nitrogen, therefore, exceeds the estimated by only $\frac{1}{70}$th.

It may be stated, then, in general terms, as the results of analyzing nitrous oxide and nitrous gas by the methods which have been described in this paper;

1stly.—That 1 volume of nitrous oxide is decomposed by 1 volume of carbonic oxide; and the products are 1 volume of carbonic acid and 1 volume of nitrogen. But to convert 1 volume of carbonic oxide into an equal volume of carbonic acid, half a volume of oxygen is required. Therefore 1 volume of nitrous oxide must be constituted of 1 volume of nitrogen + half a volume of oxygen in the space of 1 volume.

2dly.—That 6 volumes of nitrous gas require for perfect decomposition 1 volume of olefiant gas, and the gaseous products are 2 volumes of carbonic acid and 3 volumes of nitrogen. But to form 2 volumes of carbonic acid by the combustion of carbon, 2 volumes of oxygen are necessary; and 1 volume of oxygen is required to saturate the 2 volumes of hydrogen existing in 1 volume of olefiant gas. The results of this experiment, therefore, confirm the analysis both of nitrous gas and olefiant gas by other methods; for the former gas must consist of equal volumes of nitrogen and oxygen gases not condensed in bulk; and 1 volume of olefiant gas must be constituted of 2 volumes of hydrogen + carbon sufficient for forming 2 volumes of carbonic acid.

(To be concluded in our next.)

Article XVII.

SCIENTIFIC NOTICES.

Chemistry.

1. *Ignition supported by Hydrophosphoric Gas, &c.* (Extract of a Letter from M. J. B. Von Mons to M. Planche.)

I have lately observed, on kindling phosphuretted hydrogen not spontaneously inflammable, that the bubbles which are slowly generated maintain the ignition of a lighted match, without inflaming it, and are themselves inflamed by the incandescent flameless body: this has some relation to Doebereiner's lamp. You have undoubtedly already seen that hydrogen, after having burnt for some minutes in the philosophical candle, heats the end of the tube sufficiently to cause the gas to be relighted immediately after it is blown out. The hydrogen in this candle inflames spontaneously if the mixture of the sulphuric acid and the water be made in the bottle itself.—(Journal de Pharmacie.)

2. *Effect of Prussic Acid on Vegetation.*

C. I. Th. Becker (*Dissertatio de Acidi Hydrocyanici Vi perniciosâ in Plantas. Jena*, 1823. 4to.) has made many experiments, from which it follows that prussic acid prepared by Vauquelin's method destroys vegetables nearly in the same manner as it acts on animals. Seeds steeped in this acid either die or lose the power of germinating. The more delicate vegetables perish under its influence sooner than the more robust.—(Journal de Pharmacie.)

3. *To preserve the Colour of Red Cabbage.*

Digest the leaves of the cabbage in warm alcohol, and when the whole of the colouring matter is extracted distil off a portion of the spirit, and evaporate the remainder, at a very gentle heat, to the consistence of a syrup. This extract may be preserved unimpaired for years, if kept in closely stopped phials. In order to use it, it is only necessary to add a small portion of it to water, in which it is readily soluble, when the addition of an acid or an alkali will produce its peculiar effect. When we wish to employ this test to discover small quantities of carbonic acid, it is necessary to render it slightly green by the addition of a diluted alkali. The carbonic acid will then restore the blue colour, by saturating the alkali. Test papers may also be prepared by means of the alcoholic tincture of the cabbage, which, when rendered green by immersion in a diluted alkaline solution, may be used in all those cases in which litmus papers are commonly employed.—(American Journal of Science.)

4. *Note on the pretended Alkali of the Daphne.* By M. Vauquelin.

In 1808, when analyzing the *thymelea alpina* and *gnidium*, I perceived an alkaline matter, which I described as follows:—"Taste, pungent and very permanent; very volatile; acts on vegetable colours, like the alkalies." At that time, however, as the existence of an alkali of a vegetable nature was unknown (M. Seguin's discovery of such a substance in opium having been forgotten, as it were, till 1816), I did not venture to affirm that it was really a vegetable alkali; and I did well.

Since the experiments of M. Sertuerner have been known in France, and MM. Pelletier, Boullay, Lassaigne, and other chemists, have found new alkaline substances in various vegetables, I have thought it right to resume my labours on this subject. The following are the results of my researches.

Before I detail the properties of this pretended alkali, I shall describe the best processes for obtaining it pure.

First Process.—Pour one pound of boiling water over one pound of dried daphne thymelea (spurge laurel?), and digest the mixture at a temperature between 140° and 160° for some hours. Strain off the liquid, and press the residuum to obtain the whole of it, and having added to it a little lime, or potash, or even magnesia, submit it to distillation, carrying the process as far as possible without burning the residuum.

The distilled liquid is as colourless as water, very pungent, chiefly affecting the throat, has a very irritating smell, and quickly restores the blue colour of litmus previously reddened by an acid. If it be wished to have this principle in a more concentrated form, sulphuric acid in slight excess may be added to the infusion above-mentioned, the liquid reduced by careful evaporation to one-fourth, or even one-eighth of its original bulk, and an excess of magnesia then added to it, and distilled to dryness in a water bath, taking care to keep the receiver cool. This product will be four or eight times as strong as the former.

Second Process.—Make a hot infusion of the bark of the daphne thymelea in four parts of pure alcohol. Digest it in a close vessel at the temperature of 96° for three or four hours, after which decant off the brownish coloured liquid.

Distil till no more alcohol comes over; let the residuum cool, and decant the liquid to separate it from a resinous matter which falls down during the distillation of the alcohol; wash the residuum with warm water, and add the washings to the decanted liquid.

As the resin carries down with it a large quantity of the pungent principle, it must be heated, sufficiently to melt it, in water acidulated with sulphuric acid, and this liquid must be added to

that already separated from the resin, and distilled with magnesia to dryness.

If the washing of the resin be well performed, it will retain no sensible portion of the pungent principle, at least none will be perceptible to the taste.

The resin loses its green colour by being washed with the acid, and assumes an ochre yellow colour.

The distilled water, highly loaded with the pungent principle of the daphne, has an odour which irritates the nostrils violently, and shows the substance to be highly volatile. In fact, if we suspend a piece of reddened litmus paper in a flask, partly filled with the water, it is speedily restored to its original blue colour.

If a drop of the water be applied to the tongue, it does not at first produce any sensible effect; but, after a few minutes, a sharp sensation is perceived over the whole mouth, and particularly about the throat, where it continues for a long time.

The water saturates acids, and the compound formed with sulphuric or nitric acid crystallizes by slow evaporation in fine white and brilliant needles.

The water also precipitates some metallic solutions; for instance, acetate of lead in brilliant, white, satiny crystals; sulphate of copper, green; nitrate of silver, white, soon becoming rose coloured, as I also observed in my first experiments.

From these facts it seems beyond a doubt, that there exists in the daphnes a substance possessed of alkaline properties, since it acts on vegetable colours like an alkali, saturates acids, and, with some of them at least, forms crystallizable salts. But, notwithstanding these experiments, I cannot yet admit, conclusively, the presence of a vegetable alkali in the bark of the daphnes, for having neutralized a large quantity of water, saturated with the pungent principle of the daphne gnidium, I obtained by evaporation a salt which evidently contained muriate of ammonia. Hence it is possible that ammonia alone was the cause of the alkaline properties of the water distilled from the daphne, and that the pungent principle had no share in producing them.

It is not very easy to comprehend how a substance so volatile as the pungent principle of the daphne, when freed from all foreign substances, should yet keep so long in the dry bark of the daphne. I am convinced, however, that it is in less quantity in the dry bark than in the fresh. The volatilization of the pungent principle is without doubt assisted by the ammonia. It is probably retained in the bark in combination with the resin, and, perhaps, also with acids, for I found that I obtained an increased quantity of it by distilling the infusion with magnesia, or other alkaline substances.—(Journal de Pharmacie.)

5. *On the Production of Liquid Anhydrous Sulphurous Acid, and its Use in the Liquefaction of some other elastic Fluids.* By M. Bussy.

The gas is produced in a matrass from a mixture of equal parts of mercury and sulphuric acid; it first passes into a vessel surrounded with melting ice to condense the greater part of the vapour of water that comes over with it, and from thence it is conveyed through a long tube, filled with fused muriate of lime, into a small matrass surrounded by a freezing mixture, composed of two parts of ice, and one of common salt. The gas condenses in the last vessel into a liquid, under the mere pressure of the atmosphere.

The liquid acid is colourless, transparent, of sp. gr. about 1·45, and boils at a temperature of 10° below 0° (14° Fahr.). It may, however, be easily preserved a considerable time at common temperatures, for the cold produced by the volatilized portion lowers the temperature of the remainder below its boiling point. Dropt on the hand it volatilizes completely, and produces intense cold. Poured into water at the common temperature, it produces a kind of effervescence from the volatilization of part of the acid, and a thick coat of ice forms at the surface of the water. By cautiously pouring it into the water, it sometimes sinks without mixing with it, and collects in little drops at the bottom of the vessel; if these be touched with the end of a glass rod, they instantly assume the elastic form, and occasion a sort of ebullition in the water.

Mercury was readily frozen in a thermometer tube, by surrounding the ball with cotton wetted with the liquid acid, and still more conveniently, by placing a small quantity of the metal in a watch-glass, adding a little of the liquid sulphurous acid, and evaporating it under the exhausted receiver. In this way between 200 and 300 grains of mercury may easily be solidified in four or five minutes, and at the moment of congelation, irregular depressions may be observed on its surface, owing to the great contraction the metal experiences at the instant it crystallizes.

Alcohol, of the specific gravity ·852, was frozen in a bulb surrounded by cotton wetted with the liquid acid, and exposed to the vacuum of an exhausted receiver; but neither ether nor absolute alcohol could be congealed in the same manner. The latter, however, became more viscous than usual.

"I have recently succeeded in some attempts to liquefy other elastic fluids by the cold produced by the evaporation of sulphurous acid. I pass the gas, well dried by chloride of calcium, into a tube having a thin glass bulb on its horizontal branch; while the vertical branch dips into a jar containing mercury. I surround the bulb with cotton, wet it with some

drops of sulphurous acid, and promote its evaporation by a current of air; in a short time the gas condenses in the bulb. In this way I have liquefied chlorine, cyanogen, and ammonia, under a pressure of some centimetres of mercury (1 centimetre = ·39 of an inch). These are the only gases that I have as yet tried, but I have no doubt that a great many of the others may be condensed, perhaps all, by combining pressure with reduction of temperature, especially by employing liquefied ammonia, cyanogen, &c. which, being much more volatile than sulphurous acid, may produce a more considerable reduction of temperature." —(Journal de Pharmacie.)

6. *Organic Analysis by Peroxide of Copper.*

Bischof affirms that during the decomposition of vegetable substances by ignition with peroxide of copper, the carbon is seldom converted completely into carbonic acid; a portion, which sometimes amounts to as much as one-twelfth of the whole, escaping in the state of carbonic oxide, and remaining mixed with the azote. The carbon was fully peroxidized only in the case of a few compounds, such as tartaric acid, which contain naturally a large proportion of oxygen. He found some difficulty in detecting the presence of a small quantity of carbonic oxide in mixture with azote, but was most successful in obtaining a detonation with the electric spark, when the gaseous residue (after the separation of the carbonic acid) was mixed with twice or thrice its volume of oxygen. The detonation was rendered much more certain by mixing the gaseous residue with one-fourth or one-half of its volume of hydrogen; and the carbonic oxide was at the same time, by a simultaneous combustion, converted into carbonic acid.—(Schweigger's Neues Journ. vol. x. p. 25.)

We forbear entering more minutely into his experiments, as he describes his process of analysis too imperfectly to enable us to judge how far it may have influenced his results. There are three causes, all of which would probably contribute materially to the formation of carbonic oxide, and which it would be necessary, therefore, in a particular manner, to guard against. 1. The intermixture of the red with the black oxide of copper. This might have happened in some of Bischof's experiments, as he states that he occasionally used an oxide which had been prepared by igniting precipitated copper in a muffle. 2. The employment of too high a temperature. If the carbonic acid came in contact with metallic copper strongly heated, it would, not unlikely, be reduced to a lower degree of oxidation. 3. The incomplete mixture of the organic substance with the oxide of copper. In this case, as in the first, the carbon at the instant of its disengagement would be in contact with too small a quantity of oxide to be fully peroxidized.

7. *Oxalate of Lime decomposed by Potash.*

M. Laugier observed a remarkable fact, which occurred in analyzing an urinary calculus, that the oxalate of lime was completely decomposed by *potash*.

"I heated," he says, "10 parts of the calculus with a weak solution of *caustic potash*, with the intention of separating the oxalate of lime from the uric acid, whether free or combined; a process recommended by all the authors for that purpose.

"The insoluble portion, which I considered as oxalate of lime, was found to be carbonate of lime without any admixture. As the lime could only be derived from the oxalate with that base, it follows that that salt must have been decomposed by the potash; and I actually found the oxalic acid, which it had taken from the lime, in combination with the alkali. Desirous of verifying the fact, I took 100 parts of artificial oxalate of lime, and boiled it with a solution of potash, and succeeded twice in decomposing it entirely. I repeated the experiment with 20 parts of oxalate of lime detached from a mulberry calculus, harder than ivory, and by two boilings in the alkaline solution completely effected their decomposition. We must, therefore, conclude, that a solution of potash cannot be a proper agent, particularly if heat be employed, for separating oxalate of lime from substances soluble in that alkali, which almost always contains carbonic acid, or absorbs it during the operation."—(Jour. de Pharm.)

Note by the Editor of the Annales de Chimie.—The fact observed by M. Laugier entirely changes its character if we suppose the potash employed by that able chemist to have been slightly carbonated, for it is very certain that oxalate of lime is easily decomposed by carbonate of potash. We will ask, therefore, if perfectly pure potash be capable of decomposing oxalate of lime either wholly or partially?—(Annales de Chimie.)

8. *Analysis of Pinite, from St. Pardoux, in Auvergne.*

Dr. Gmelin's analysis of this mineral gives its composition as follows:

Silica	55·964
Alumina (with traces of lime)	25·480
Potash	7·894
Soda	0·386
Oxide of iron	5·512
Magnesia, with oxide of manganese	3·760
Water with an animal matter	1·410
	100·406

Fluoric acid was sought for, but not found. The preceding

results, in Dr. Gmelin's opinion, prove such an affinity between pinite and mica, in regard to chemical composition, that they can no longer be considered as generically separate. "The circumstance that pinite contains no fluoric acid cannot be considered as an essential difference, when it is observed that even those varieties of mica which occur in primitive limestones, contain very little of that acid, or are entirely destitute of it, according to the experiments of H. Rose: fluoric acid ought not, therefore, to be considered as an essential constituent of mica." —Edin. Phil. Journ.

Dr. Gmelin gives the specific gravity of pinite = 2·7575 at 46°; according to Phillips, it is 2·98.

9. *Analysis of Cinnamon-stone, from Ceylon.*

Dr. Gmelin has confirmed the accuracy of Klaproth's statement of the composition of the cinnamon-stone (Beitrage, vol. v. p. 142) by a recent analysis conducted in a very different manner. His results give its composition as,

Silica	40·006
Alumina	22·996
Lime	30·573
Oxide of iron	3·666
Potash	0·589
Manganese	Trace
Volatile matter	0·326
	98·156

In the course of the analysis, Dr. Gmelin digested a precipitate, which had been thrown down by caustic ammonia, in a considerable excess of carbonate of ammonia. "The liquid was separated by the filter from the undissolved part, and evaporated. A white substance fell down. Considering the manner in which this substance had been obtained, one might have taken it for glucine, ittria, or zircon, but it was pure alumina; and when dissolved in sulphuric acid by digestion, and mixed with a little ammonia, it crystallized entirely into alum. It follows, hence, that when alumina is precipitated by means of carbonate of ammonia, it is not advisable to add the latter in great excess; and that the common method used to separate glucine from alumina does not yield it pure."—(Edin. Phil. Journ.)

Mineralogy.

10. *Singular Form of Crystals of Sahlite.*

Prof. Silliman found, near Greenwood Furnace, in Munroe, about 20 miles south of Newburgh, in a small excavation which had been made in searching for iron ore, crystals of green augite, of the variety called sahlite, in a rock principally com-

posed of augite, naturally divided by fissures into fragments easily separated by the pickaxe. The soil was strongly impregnated with oxide of iron, and probably carbonate of lime. The crystals were generally found on the edges and surfaces of the fragments, but sometimes imbedded in carbonate of lime; the latter have generally a deeper green colour than the former.

"A vein of green mica, about one foot in breadth, and several feet in depth, passed through the rocks, on the borders of which nearly all the crystals were found. When first taken from the earth they broke with great ease; on exposure, they soon hardened, and when perfectly dry became quite firm. Their size varies from extreme minuteness to five or six inches in circumference; their length from three-fourths of an inch to three inches; but some are both longer and larger. It was not uncommon to find, on breaking the larger crystals, small lumps of oxide of iron and specks of mica within them, and in some cases six-sided crystals of mica enter the sides of the sahlite crystals. Of the number of these no estimate can be formed; there are thousands about the size of the finger, and myriads of those which are smaller. The positions of the clusters are very variable; some, as has been remarked, are on the corners, edges, and surfaces of the fragments of the augite rock; others lie in nests, like geodes within the surface. The crystals are grouped together in numberless fantastic modes, intersecting, lying on and passing through each other at all angles, usually without producing any alteration in their respective forms. When, however, one passes across the truncated edge of another, an alteration in the depth of the truncation is often the consequence. From a similar cause, and sometimes without any apparent one, a very different and singular appearance is exhibited—*re-entering angles.* These appear sometimes instead of a truncation, and sometimes in the middle of one. In both these instances, the faces containing the re-entering angle are parallel to the sides of the primitive parallelopiped. Occasionally such an angle, very obtuse, is produced by a truncation passing only part of the way across the edge, when of course the angle is contained by one face of the primitive, and the face forming the partial truncation. It is not often that more than one of these angles is found on a crystal; occasionally two, which are generally on opposite edges of the primitive though I have found one or two where they occurred on adjacent ones. A perfect notion of all these cases will be conveyed by sections parallel to the base. (See Plate XXXII, figs. 1, 2, 3, 4, and 5.)

"Crystals of the form indicated by fig. 3, occur more frequently than the others. It has eleven faces. Fig. 4 shows one with fourteen. The terminations of these crystals are like those which are eight-sided, and from an inspection of the laminæ, which are distinctly visible, they seem to be single crystals. I

am aware that writers on crystallography do not admit the existence of re-entering angles in single crystals; but I must own my inability to detect any signs of those which I speak of being double.

"There are also some instances of peculiarity in the forms of summits which it may be worth while to notice. I can think of no better way to give a just notion of that to which I refer than the following:—Suppose a person to be forming a crystal by placing laminæ of the proper form upon each other, till he had commenced forming the summit by laminæ of smaller dimensions; but after the summit was partially formed should determine to carry the crystal higher in a form similar to the lower part, and after having done so for perhaps half an inch, should then finish with a summit. In some cases the appearance is as if this process had been repeated the second time before the last summit was formed. The partial summits are sometimes like the ultimate ones, sometimes unlike. It is impossible, however, within the limits of this paper, to notice all the interesting appearances exhibited on these crystals. Of themselves, they might form a copious volume for the crystallographer to study." —(American Journal of Science.)

11. *American Localities of certain Minerals and Fossils.*

A new variety of quartz has been found in Chester, Massachussetts, by Dr. Emmons. It is distinctly laminated, the folia separate by a blow, like those of laminated calcareous spar. It is partially translucent, though the faces of the laminæ have not a perfect crystalline smoothness, and are marked with oblique striæ.

Prismatic mica occurs in Chester, in fine filaments, which gradually pass into *rhombic* prisms. It is abundant and beautiful. The fibres are often "as delicate as those of amianthus."

Cummingtonite.—Prof. Dewey has given this name to a variety of epidote, found at Cummington, Massachussetts. "Its colour is grey, sometimes with a faint reddish tinge, unless when acted on by the weather, when its colour is yellowish. It is in indistinct prisms, with oblique seams like zoisite, and in radiated or fascicled masses, which are composed of slender prisms. Lustre somewhat shining or pearly. It is nearly as hard as quartz, and sometimes makes a slight impression upon rock crystal. Before the blowpipe it blackens, and a small portion melts, when the heat is very great, into a black slag, which is attracted by the magnet. Its point of fusion seems to be about that of zoisite. After allowing for some absorption, the specific gravity may be taken as about 3·42. It is so peculiar a mineral, that it deserves, even as a variety, a particular name.

"With quartz and garnet, it forms a large mass in Cummington. The cavities in the rock contain pulverulent sulphur of a

dirty greenish colour; and minute crystals of magnetic oxide of iron are also found in it."

"*Petalite.*—This rare mineral, not hitherto found on this continent, occurs on the north shore of Lake Ontario, on the beach in front of York, the capital of Upper Canada. It is a rolled mass weighing about a ton, and has much glassy tremolite interspersed, and two large veins of irregular shape, of an aggregate of actynolite and calcareous spar. Close to this bowlder lies a still larger of the ophicalcic family (a term used by the French geologists to designate a rock composed of marble and serpentine) from Grenville, or Gananoque, and strewn around are loose greenstones, sienites, and some Labrador feldspar."

The secondary limestone of the St. Lawrence and its lakes, is particularly rich in the number, novelty, and beauty of its organic remains. In addition to many which are unknown elsewhere, it abounds throughout its vast extent in those fossils which are supposed to characterise the carboniferous limestone. A great many of these substances have been described in the second part of the sixth volume of the Transactions of the Geological Society. No impressions of fish, nor of vegetables, have hitherto, according to Dr. Bigsby (from whose paper this part of our extract is taken), been discovered in the Canadas.

The fossils enumerated by Dr. Bigsby are, *Trilobite*, an exceedingly numerous, and almost universal family, always found in fragments, but not unfrequently containing the greater part of the fossil, with the remainder lying close by.

"I have by me at present a fine but imperfect impression from the cast of an undescribed trilobite from the isles on the north shore of Lake Huron. It is a pretty exact oval, rather exceeding five inches in length, and two and a half in breadth. The total length appears to have been six inches. It is not clear which end represents the 'bouclier;' except we judge from the position of the articulations, which are eleven in number, each one-fifth of an inch broad, the upper one being an inch and a half from the summit of the supposed bouclier. Of the three lobes, the middle one is much the largest, that on each side being only five-eighths of an inch broad, and being not quite so protuberant as the first mentioned lobe, which itself has a moderate and gradual convexity. All parts of this remain are full of small transverse curved tracings, more or less parallel to each other."

Ammonite.—Casts of ammonites are found on the shores of the Lakes Huron, Simcoe, and Ontario.

Orthoceratites.—Found everywhere in immense quantities. In Lake Huron they sometimes occur five feet long, but in the Lake of the Woods and Lake Simcoe, little more than an inch in length. "Major Delafield's collection contains a flattened

orthoceratite from Lake Huron, seven inches long, nearly two inches broad at one end, and one inch and a quarter at the other. One face of the fossil presents the usual cellular divisions; but the reverse exhibits the appearances exhibited in fig. 12 (Pl. XXXII). At the larger end of this specimen, the siphuncle is of great magnitude; but at the smaller, it is not much more than a quarter of an inch in diameter. Its chambers are very unequal."

"The isles on the north of Lake Huron possess a curious and complicated chambered shell which approaches nearest to an orthoceratite. There are at least three varieties."

Conularia.—Three specimens of C. quadrisulcata were found at the falls of Montmorenci.

Euomphalus, Trochus, and *Turbo,* are the only unchambered univalves that Dr. Bigsby found in Lake Huron.

Terebratulæ abound everywhere. The most common species are T. bicarinata of Lesueur, and T. subrotunda.

Productæ.—Abundant in almost every locality. They are often of chert.

Encrinis.—E. prominens, E. verrucosa, and E. lævis, together with pentacrinital columns are plentiful every where, but rarely with ramifications or stomach.

Caryophyllia have been found in great numbers in the south of Lake Erie.

Turbinolia.—This species of madrepore abounds in the Lake of the Woods, and the great lakes, but is much more rare at Montreal and Quebec.

Astræa.—*A. basaltiformis* in the limestone of the river Detroit?

Cellular and chain madrepores, tubipa strues, and ramosa, retepores, and flustra, are in great abundance everywhere.

Nine varieties of a new genus of madrepore, having the form of a vertebral column, sometimes two feet long, were discovered at the Manitoulines of Lake Huron, by Mr. White, the medical officer of the British military station on Drummond's Island. They have been described in the Geological Transactions.

"The following shells are known only in the more recent formations. The delicate bivalve, the lingula (crag, London clay), occurs in considerable numbers among the trilobites and orthoceratites of Lake Simcoe, and in well-marked specimens. They are oval, or suboval, and rather longer than half an inch. They are casts which frequently retain the original shell of a glossy hair-brown colour.

"Mr. Say, of Philadelphia (to whom I am under many obligations), pronounced with great hesitation, on account of accidental defects, or the concealment of the hinge, upon what he supposed to be the clypeaceous univalve, calyptræa (crag above London clay), from Lake Simcoe, an unio (cornbrash, &c.), a mytilus (coral rag, &c.), both from the north-east coast of Lake

Huron; gryphæa (lias), from Lakes Superior and Simcoe, arca (lias), Lake Simcoe, and sanguinolaria, River Humber, Lake Ontario."—(American Journal of Science.)

12. *Analyses of Chrysoberyls from Haddam, in Connecticut, U. S. and Brazil.* By Mr. H. Seybert.

The Haddam chrysoberyl occurs in a coarse-grained granite, in which the predominating ingredient is albite, and is associated with greyish-quartz, manganesian garnet, and beryl. The mineral was extremely refractory when fused with caustic potash, an effect ascribed by Mr. Seybert to the glucina being mixed with a very small portion of titanium. He succeeded in effecting its decomposition by repeatedly fusing it with caustic potash, and when the alkali had no further action, calcining the residuum several times with nitrate of barytes. His results give its composition as follows:

Moisture	0·40
Oxide of titanium	1·00
Glucina	15·80
Silica	4·00
Alumina	73·60
Protoxide of iron	3·38
	98·18
Loss	1·82
	100·00

Mr. Seybert found the chrysoberyl from Brazil to consist of

Water	0·666
Oxide of titanium	2·666
Glucina	16·000
Silica	5·999
Alumina	68·666
Protoxide of iron	4·733
Loss	1·270
	100·000

(American Journal of Science.)

13. *Description and Analysis of Sillimanite, a new Mineral from Saybrook, in Connecticut, U. S.* By Mr. G. T. Bowen.

This mineral has been mistaken for anthophyllite, and is so called in the last edition of Cleaveland's Mineralogy. Its colour is dark grey, passing into clove brown. It occurs in a vein of quartz, penetrating gneiss, crystallized in rhomboidal prisms, whose angles are about 106° 30′ and 73° 10′; the inclination of the base to the axis of the prism being about 113°. It

has but one cleavage which is parallel to the longer diagonal of the prism. The sides and angles of the crystals are frequently rounded.

Its hardness exceeds that of quartz: even topaz may be scratched by some of the specimens. It is translucent on the edges, and in small fragments; it is brittle, and easily reduced to powder.

Its fracture, in the direction of the longer diagonal, is lamellar, and displays a brilliant lustre; the cross fracture is uneven and splintery.

It does not become electric either by heat or friction, nor give any indications of magnetism.

Its specific gravity is 3·41.

Before the blowpipe, it is infusible *per se*, and also when heated with borax.

The nitric, muriatic, and sulphuric acids, have no action on its powder.

From Mr. Bowen's analysis, sillimanite is composed of

Water	0·510
Silica	42·666
Alumina	54·111
Oxide of iron	1·999
Loss	0·714
	100·000

(American Journal of Science.)

Miscellaneous.

14. *Extraordinary Extent of the Baise and Flannel Manufacture at Rochdale.*

"In the town of Rochdale and the adjacent villages, there are manufactured every week, of flannels and baizes, about 20,000 pieces, of 46 yards each, making 47,840,000 yards per annum. It is supposed that 17,840,000 yards are exported; the remaining 30 millions of yards are consumed in the United Kingdom, being an average of $1\frac{1}{4}$ yard for each individual. Some good flannels are manufactured in Wales; a few coarse ones at Keswick; and some other towns and villages in the kingdom. A few are manufactured on the Continent, and works for that purpose are now erecting in America; but the whole of the flannels manufactured on the globe, besides those manufactured in Rochdale and its immediate vicinity, are not equal in quantity to those made there. The price of flannels is 5*d.* to 3*s.* per yard; and the average may be stated at from 13*d.* to 14*d.* per yard; so that the annual value of the manufacture may be stated at about 3,000,000*l.* sterling. The wool costs fully one-half of the wholesale selling price; the oil, labour, and finishing, &c. constitute nearly the other half."—(Edin. Phil. Jour.)

15. *Electromagnetic and Galvanic Experiments.* By Dr. Hare.

If a jet of mercury, in communication with one pole of a very large calorimotor, is made to fall on the poles of a very large horse-shoe magnet communicating with the other, the metallic stream will be curved outwards or inwards, accordingly as one or the other side of the magnet may be exposed to the jet, or as the pole communicating with the mercury may be positive or negative. When the jet of mercury is made to fall just within the interstice formed by a series of horse-shoe magnets, mounted in the usual way, the stream will be bent in the direction of the interstice, and inwards or outwards, according as the sides of the magnet, or the communication with the galvanic poles, may be exchanged. The result is analogous to those obtained by Messrs. Barlow and Marsh with wires, or wheels.

It is well known that a galvanic pair, which will, on immersion in an acid, intensely ignite a wire connecting the zinc and copper surfaces, will cease to do so after the acid has acted on the pair for some moments, and that ignition cannot be reproduced by the same apparatus, without a temporary removal from the exciting fluid.

I have ascertained that this recovery of the igniting power does not take place, if, during the removal from the acid, the galvanic surfaces be surrounded either by hydrogen gas, nitric oxide gas, or carbonic acid gas. When surrounded by chlorine, or by oxygen gas, the surfaces regain their igniting power in nearly the same time as when exposed to the air.

The magnetic needle is nevertheless much more powerfully affected by the galvanic circuit, when the plates have been allowed repose, whether it take place in the air, or in any of the other gases above mentioned.—(American Journal of Science.)

Article XVIII.

NEW SCIENTIFIC BOOKS.

PREPARING FOR PUBLICATION.

A Translation of the Travels of the Prussian General Baron Minutoli, in Lybia and Upper Egypt; illustrated with Maps and Plates.

The First Volume of the Lectures of Sir Astley Cooper, Bart. on the Principles and Practice of Surgery, as delivered at St. Thomas's and Guy's Hospitals. With additional Notes and Cases, by Frederick Tyrrel, Esq. Surgeon to St. Thomas's Hospital.

A Practical Treatise on Prisons, and an Inquiry into the Duties and Perplexities of Medical Men as Witnesses in Courts of Justice. By Dr. J. G. Smith.

JUST PUBLISHED.

Bees on Tic Doloreux. 8vo. 7*s.* 6*d.*
Magendie's New Remedies, with Appendix. 5*s.* 6*d.*
Halloran on Opthalmia. 5*s.*
Manuale Medicum, or Medical Pocket Book for Students. 5*s.*
Thomson's London Dispensatory. 8vo. 15*s.*
The Young Brewer's Monitor, comprising a scientific Summary of the Art, with a Series of Cautionary Precepts, &c. 8vo.

Article XIX.

NEW PATENTS

C. Jefferies, Havanah Mills, near Congleton, silk thrower, and E. Drakeford, Congleton, watch-maker, both in the county of Chester, for their invented method of making apparatus for the purpose of winding silk and other fibrous materials.—July 29.

W. Wheatstone, Jermyn-street, St. James's, music seller, for his invention of improving and augmenting the tones of piano-fortes, organs, and euphonons.—July 29.

J. Price, Stroud, Gloucester, engineer, for certain improvements in the construction of spinning machines.—Aug. 5.

G. Graydon, Bath, Captain in the Royal Engineers, for inventing a new compass for navigation and other purposes.—Aug. 5.

W. Johnson, Great Tothan, Essex, for inventing a means of evaporating fluids for the purpose of conveying heat into buildings for manufacturing, horticultural, and domestic uses, and for heating liquors in distilling, brewing, and dyeing, and in making sugar and salt with reduced expenditure of fuel.—Aug. 5.

J. Perkins, Fleet-street, engineer, for certain improvements in propelling vessels.—Aug. 9.

J. Fussell, Mells, Somerset, edge-tool-maker, for his improved method of heating woollen cloth, for the purpose of giving it a lustre in dressing.—Aug. 11.

H. Schroder, Hackney, broker, for his invented new filter.—Aug. 11.

J. Vallance, Brighton, for his improved method of abstracting or carrying off the caloric of fluidity from any congealing water (or it may be other liquids): also an improved method of producing intense cold: also a method of applying this invention so as to make it available to purposes, with reference to which temperatures about or below the freezing point may be rendered productive of advantageous effects, whether medical, chemical, or mechanical.—Aug. 28.

J. Neville, High-street, Southwark, engineer, and W. Busk, Broad-street, for certain improvements in propelling ships' boats, or other vessels, or floating bodies.—Sept. 16.

Article XX.

METEOROLOGICAL TABLE.

1824.	Wind.	Barometer. Max.	Barometer. Min.	Thermometer. Max.	Thermometer. Min.	Evap.	Rain.
8th Mon.							
Aug. 1	N W	30·13	29·82	63	43	—	10
2	N W	30·14	30·11	75	55	—	—
3	S W	30·11	30·01	75	56	—	11
4	N	30·01	29·89	72	58	—	06
5	N W	29·89	29·81	70	55	—	03
6	S W	30·00	29·84	69	48	—	02
7	N	30·05	30·01	75	52	—	06
8	S W	30·01	29·86	70	62	—	04
9	W	29·97	29·86	73	52	—	
10	W	29·97	29·65	75	60	·95	—
11	S W	29·90	29·65	75	56	—	
12	S W	29·99	29·90	75	52	—	
13	N W	30·12	29·99	73	47	—	60
14	N W	30·13	29·87	69	52	—	
15	S W	30·12	29·85	64	47	—	56
16	W	29·95	29·85	70	50	—	
17	S W	29·85	29·82	70	52	—	12
18	W	29·91	29·82	66	56	·90	15
19	N W	29·94	29·91	69	55	—	05
20	S	29·95	29·90	71	59	—	04
21	N W	30·15	29·90	72	52	—	07
22	N	30·23	30·15	70	49	—	
23	N	30·34	30·23	72	46	—	
24	N E	30·42	30·34	67	48	—	
25	N	30·42	30·40	76	49	—	
26	N E	30·40	30·38	73	52	—	
27	N E	30·38	30·14	73	55	·75	
28	N E	30·14	30·06	77	50	—	
29	E	30·06	30·04	82	53	—	
30	S E	30·04	30·03	80	60	—	—
31	N	30·11	30·03	76	55	·35	
		30·42	29·65	82	43	2·95	2·01

The observations in each line of the table apply to a period of twenty-four hours, beginning at 9 A. M. on the day indicated in the first column. A dash denotes that the result is included in the next following observation.

REMARKS.

Eighth Month.—1. A gentle rain till noon. 2. Fine. 3. Fine day: rain at night. 4—7. Cloudy. 8. Cloudy, with showers. 9. Fine. 10. Cloudy and fine. 11, 12. Fine. 13. Showery. 14. Fine. 15. Rainy. 16. Fine. 17. Fine day: rain at night. 18. Day fine: a thunder storm about six, p. m. 19. Cloudy. 20. Overcast. 21. Showery. 22—31. Fine.

RESULTS.

Winds: N, 6; NE, 4; E, 1; SE, 1; S, 1; SW, 7; W, 4; NW, 7.

Barometer: Mean height

For the month	30·032 inches.
For the lunar period, ending the 17th	30·030
For 14 days, ending the 11th (moon south)	29·927
For 14 days, ending the 25th (moon north)	30·051

Thermometer: Mean height

For the month	62·467°
For the lunar period	62·433
For 31 days, the sun in Leo	62·338

Evaporation	2·95 in.
Rain	2·01

Laboratory, Stratford, Ninth Month, 23, 1824. R. HOWARD.

ANNALS

OF

PHILOSOPHY.

NOVEMBER, 1824.

Article I.

On the Use of Gold Leaf as a Test of Electromagnetism. By the Rev. J. Cumming, Professor of Chemistry in the University of Cambridge.

(To the Editors of the *Annals of Philosophy.*)

GENTLEMEN, *Cambridge, Sept.* 21, 1824.

In the instrument which I constructed between three and four years since for the detection of minute quantities of electromagnetism, the test employed was the action of the connecting wire on a magnetised needle; I have lately applied to this purpose the reverse principle, viz. the action of a magnet upon the connecting wire by making a slip of gold leaf a part of the circuit. The instrument is readily constructed by substituting for the two slips of gold leaf in Bennet's electrometer a single slip suspended from the wire of the upper plate, and resting upon the metallic base.

Though not so delicate a test of electromagnetism as the galvanoscope above alluded to, yet with even a feeble power, I find it to be very sensible to the action of a small horse-shoe magnet; and it may, perhaps, be considered as an advantage peculiar to this instrument, that it exhibits the *magnetic* action of the closed circuit by a modification of the same apparatus which is used for detecting the *electric* action of the circuit when open. I am, Gentlemen, very truly yours,

J. Cumming.

Article II.

On the Solution of $\psi^n x = x$. By John Herapath, Esq.

(To the Editors of the *Annals of Philosophy*.)

GENTLEMEN, *Cranford, Oct.* 5, 1824.

Since the publication of Mr. Babbage and Mr. Herschel's beautiful researches on periodical functions, the extension of the functional calculus is become a subject of considerable interest. Among the first and most useful parts of functions stands the solution of

$$\psi^n x = x \ldots\ldots\ldots (1)$$

Indeed this solution is the hinge on which all further inquiries must naturally turn. Limitations, therefore, in this part, unavoidably beget limitations in the higher operations, and thus deprive the calculus of its chief excellence, unbounded generality. All the solutions of (1) I have yet met with are confined to the evaluation of ψx from positive integral values of n. In the following pages I have sought the value of $\psi^v x$ generally from the simple condition $\psi^n x = x$, without assuming any relation between v and n, or any limitation to their values. This I have effected, first by indirect methods, as it has usually been done, and then by a direct process extremely simple and general. A few observations suggested by the preceding solutions are afterwards added, respecting the number of arbitrary functions in the complete solution of (1), which it is hoped will settle that important question.

Lemma.—If $\psi^v x = \alpha x$, αx being any function of x; then $\psi^{vp} x = \alpha^p x$ and $\psi^n x = \alpha^{\frac{n}{v}} x$, whatever be the values of p, n, v.

For since $\psi^v x$ is supposed equal to αx for all values of x, ψ^v must be of the same form as α; and, therefore, any operation on ψ^v as a whole by whatever index denoted must be identical with the same operation on α. That is $\alpha^p = (\psi^v)^p$ or $\psi^{vp} x = \alpha^p x$.

Whence if $p = \frac{n}{v}$, $\psi^n x = \alpha^{\frac{n}{v}} x$.

§ 1. Assuming $\alpha x = b x$, we get

$$\alpha^2 x = b^2 x,$$
$$\alpha^3 x = b^3 x,$$
$$\ldots\ldots\ldots$$

and generally $\psi^n x = b^n x$ by the preceding Lemma for every value of n. If, therefore,

$$\psi^n x = \alpha^n x \text{ and } b^n = 1,$$

we have

$$\psi^v x = 1^{\frac{v}{n}} . x \ldots\ldots\ldots\ldots (2)$$

which by introducing an arbitrary function, according to Mr. Babbage's method, becomes

$$\psi^v x = \varphi^{-1} . 1^{\frac{v}{n}} \varphi x \ldots\ldots\ldots (3)$$

for the general solution of (1) whatever be the values of v and n. When $v = 1$, this expression gives

$$\psi x = \varphi^{-1} . 1^{\frac{1}{n}} \varphi x \ldots\ldots\ldots (4)$$

That excellent mathematician Mr. Herschel has given in Mr. Babbage's 11th Prob. Phil. Trans. for 1815, a different expression for the value of ψx; namely, $\psi x = \varphi^{-1}\{(-1)^{\frac{1}{n}} \varphi x\}$; but by what we have shown, this is the solution of $\psi^n x = -x$ not of $\psi^n x = x$.

Putting (3) under the form for the circular root of 1, we have

$$\psi^v x = \varphi^{-1}\left\{\left(\cos\frac{2kv\lambda}{n} \pm \sqrt{-1} . \sin\frac{2kv\lambda}{n}\right)\varphi x\right\} \ldots. (5)$$

in which λ is the semiperiphery to radius 1, and k is any integer. And because $\cos\frac{n+a}{n}\lambda = \cos\frac{n-a}{n}\lambda$ and $\sin\frac{n+a}{n}\lambda = -\sin\frac{n-a}{n}\lambda$, if we expound k by $\frac{n \pm a}{2}$ the double sign of (5) will occasion its values to circulate and to return for all magnitudes of k into the same which take place between $k = 1$ and $k = \frac{n}{2}$ or $\frac{n-1}{2}$, as n happens to be even or odd, or between $a = o$ or 1 and $a = n - 2$, the increments of a being 2. It is also evident if n be an integer, that the number of functional roots will be n, and if n be a fraction, the number of roots will be equal to the units in the numerator of this fraction; so that if n be irrational or imaginary, the number of functional roots will be infinite.

This solution being performed by the coefficient may be called the coefficiential solution.

§ 2. Taking $\alpha x = x^b$, we have

$$\alpha^2 x = x^{b^2},$$
$$\alpha^3 x = x^{b^3},$$
$$\ldots\ldots\ldots$$
$$\alpha^n x = x^{b^n},$$

whatever be the value of n. Hence if $b = 1$, and introducing the arbitrary function

$$\psi^v x = \varphi^{-1} . \varphi x^{\frac{v}{n}} \ldots\ldots\ldots (6)$$

which is another general solution of (1), and being obtained by means of the exponent may be called the exponential.

The exponent in this case being put under the same form as the coefficient in the former case, admits the same observations with respect to the functional roots, &c. We may combine these two solutions, and have

$$\psi^v x = \varphi^{-1} . 1^{\frac{v}{n}} \varphi x^{\frac{v}{n}} \ldots\ldots\ldots (7)$$

In this solution the coefficient $1^{\frac{v}{n}}$ may be, but is not necessarily the same root as $1^{\frac{v}{n}}$ the exponent; that is, the indeterminate integers k of the coefficient and exponent are not necessarily the same. Hence the number of functional roots in this expression is n^2. For example, if $n = 2$, $v = 1$, and $\varphi x = x$, the number of roots is four,

$$x, -x, \frac{1}{x}, -\frac{1}{x}.$$

This remark, therefore, destroys the opinion derived from the analogy of algebraic equations, namely, that the functional equation $\psi^n x = x$, n being a positive integer, has as many roots only as n contains integers. It is indeed evident from the nature of arbitrary functions, that the number of functional roots is indefinite, when the arbitrary function has its full scope; but when the arbitrary function is excluded, and not in any way anticipated, the number of functional roots is the same as the number of algebraic roots of an equation of equal dimensions. In the preceding instance the arbitrary function is in part anticipated by the double solution; and hence the reason that the number of functional roots exceeds those denoted by the index.

§ 3. If we set out with a function of the form

$$\frac{a + bx}{c + dx}$$

the 2d, 3d, 4th, &c. functions will evidently be of the same form. And because a, b, c, d, are indefinite, any function of this form may be conceived to be the 2d, 3d, or rth function of a like form; so that we may suppose

$$\psi^r x = \frac{a_r + b_r x}{c_r + d_r x} \text{ and } \psi^t x = \frac{a_t + b_t x}{c_t + d_t x}$$

whatever be the values of r and t.

Because

$$\psi^r \psi^t x = \psi^t \psi^r x = \psi^{r+t} x,$$

it is manifestly immaterial whether in the value of $\psi^r x$ we substitute for x the value of $\psi^t x$, or in the value of $\psi^t x$ we substitute for x the value of $\psi^r x$; both results will be the same. Making, therefore, these substitutions, and equating the corresponding terms of the results, we obtain

$$a_{r+t} = a_t b_r + a_r c_t = a_r b_t + a_t c_r \ldots\ldots\ldots (8)$$
$$b_{r+t} = b_t b_r + a_r d_t = b_r b_t + a_t d_r \ldots\ldots\ldots (9)$$
$$c_{r+t} = c_t c_r + a_r d_t = c_r c_t + a_t d_r \ldots\ldots\ldots (10)$$
$$d_{r+t} = b_t d_r + c_r d_t = b_r d_t + c_t d_r \ldots\ldots\ldots (11)$$

By (9) or (10) $a_r d_t = a_t d_r$; therefore, when $a_r = o$, $d_r = o$, and by (8) or (11) at the same time $b_r = c_r$. This circumstance has been noticed by Mr. Horner. If also $a_t = \infty$, $d_t = \infty$; for $\frac{a_t}{d_t} = \frac{a_r}{d_r} = \frac{a_o}{d_o} = \frac{\pm o}{o}$ = some finite positive or negative quantity. Supposing $t = o$, equas. (8) and (11) give $a_o = o$, $d_o = o$, and $b_o = c_o = 1$, which brings out the obvious case

$$\psi^o x = x.$$

Because when $a_{r+t} = o$, $b_{r+t} = c_{r+t}$, we have (9) and (10) $b_r b_t = c_r c_t$. That is the product of any two, and, therefore, of any other number of the component values of b which give a resultant value for $a = o$ is equal to the product of two, or of the same number of corresponding component values of c; consequently if $b_t = \infty$, $c_t = \infty$; for $\frac{b_t}{c_t} = \frac{b_r}{c_r} = \frac{b_o}{c_o} = 1$.

Assuming $A_v = \frac{a_{vr}}{a_r}$ and $t = (v-1)r$, we obtain by (8)

$$A_v = A_{v-1} b_r + c_{(v-1)r}$$

or,

$A_v = A_{v-1} b_r + d_r a_{(v-2)r} + c_r c_{(v-2)r} = A_{v-1} b_r + a_r d_r A_{v-2} + c_r c_{(v-2)r}$ by taking $t = (v-2)r$ in (10). Again substituting $v-1$ for v in the preceding value of A_r and putting the value of $c_{(v-2)r}$ thus derived for its equal in the second value of A_r, we shall have

$$A_v - p A_{v-1} - q A_{v-2} = o \ldots\ldots\ldots (12)$$

supposing $p = b_r + c$, and $q = a_r d_r - b_r c_r$. In like manner it is found that

$$B_v - p B_{v-1} - q B_{v-2} = o \ldots\ldots\ldots (13)$$
$$C_v - p C_{v-1} - q C_{v-2} = o \ldots\ldots\ldots (14)$$
$$D_v - p D_{v-1} - q D_{v-2} = o \ldots\ldots\ldots (15)$$

where $B_v = b_{vr}$, $C_v = c_{vr}$, and $D_v = \frac{d_{vr}}{d_r}$. Each equa. (12), (13), (14), (15), is evidently an equa. of differences of the second order with respect to v, the coefficients p, q, being constant in relation to this v. The solution of either of them (13), for instance, by the usual methods, is

$$B_r = \frac{Q\left(\frac{p}{2} + \sqrt{\frac{p^2}{4} + q}\right)^v + Q_1\left(\frac{p}{2} - \sqrt{\frac{p^2}{4} + q}\right)^v}{2} \ldots\ldots (16)$$

in which Q, Q_1 are the arbitrary constants. Now if we assume $q = -\left(\frac{p}{2\cos z}\right)^2$ and identify (16) with the well-known theorem

$$(\cos z \pm \sqrt{-1}\ \sin z)^v = \cos v\,z \pm \sqrt{-1}\sin v\,z$$

we get

$$2\,B_v = \left(\frac{p}{2\cos z}\right)^v . \{ Q\,(\cos v\,z + \sqrt{-1}\sin v\,z) + Q_1\,(\cos v\,z - \sqrt{-1}\sin v\,z)\} \ldots\ldots\ldots\ldots (17)$$

Determining now Q, Q_1 from the conditions of (17) when $v = o$ and $v = 1$, we shall find after due reductions

$$Q = 1 - \frac{(b_r - c_r)\sqrt{-1}}{(b_r + c_r)\tan z}$$

$$Q_1 = 1 + \frac{(b_r - c_r)\sqrt{-1}}{(b_r + c_r)\tan z}$$

And if R, R_1 be the corresponding arbitrary constants in the solution of (14), we easily perceive that

$$R = Q_1 \text{ and } R_1 = Q.$$

Consequently

$$B_v = \frac{(b_r + c_r)^v}{(2\cos z)^v} . \left\{\cos v\,z + \frac{(b_r - c_r)\cos z \,.\, \sin v\,z}{(b_r + c_r \sin z}\right\} \ldots\ldots\ldots (18)$$

and C_v is the same expression with a negative instead of a plus sign before the second number under the vinculum $\{\ \}$.

In the same way if P, P_1 be the arbitrary constants of (12), it appears that $P = -P_1$ and

$$P = \left(\frac{b_r + c_r}{2\cos z}\sqrt{-1}\sin z\right)^{-1}$$

Whence

$$a_{v\,r} = a_r\,A_v = \left(\frac{b_r + c_r}{2\cos z}\right)^{v-1} . \frac{\sin v\,z}{\sin z}\,a_r \ldots\ldots\ldots (19)$$

Moreover since $\frac{a_{v\,r}}{a_r} = \frac{d_{v\,r}}{d_r}$, we obtain by introducing for d_r its value $\frac{q + b_r c_r}{a_r}$, and substituting for q its value $-\frac{(b_r + c_r)^2}{(2\cos z)^2}$

$$d_r D_v = d_{v\,r} = \frac{(b_r + c_r)^{v-1} . (2\,b_r c_r \cos 2z - b_r^2 - c_r^2)\sin v\,z}{(2\cos z)^{v-1} . 2\,a_r(\cos 2z + 1)\sin z} \ldots\ldots\ldots (20)$$

Having now obtained general values for the coefficients in $\psi^{v\,r} x$, let us consider a little the limitations of the indeterminate quantity z. In the first place, it is plain that z must vary independently of v; and in the next, it appears from $q = -\frac{p^2}{(2\cos z)^2}$ $= -\frac{(b_r + c_r)^2}{(2\cos z)^2} = a_r d_r - b_r c_r$ that z must never be $\frac{\lambda}{2}, \frac{3\lambda}{2}, \frac{5\lambda}{2}$, &c. because then $(\cos z)^2 = o^2$, which, unless $b_r = -c_r$, gives $a_r d_r = -(\infty)^2$, that is, both a_r and d_r infinite, the one negative, and the other positive. Thirdly, z must never be a 0, 1, 2, 3, &c.

multiple of λ, for that would give $a_{v\,r} = \frac{(b_r + c_r)^{v-1}}{2^{v-1}}\, v\, a_r$, a value which could never become $= 0$ by any finite value to v, unless at the same time $b_r = -c_r$; and, therefore, the function could never be periodic. Fourthly, z must be such that when $v = n$, the order of the periodic function, $\sin v z$ must be $= o$. Assume therefore $z = \frac{k\lambda}{n}$, and it is evident the first condition is satisfied by k being any independent variable; the second by its never becoming a $\frac{1}{2}$, $\frac{3}{2}$, $\frac{5}{2}$, &c. multiple of n, and the third by its never being a 0, 1, 2, 3, &c. multiple of the same index unless simultaneously $b_r = -c_r$. Finally, the fourth case is satisfied by k having integral values only; for otherwise k varying independently of v could not generally give $\sin \frac{v k \lambda}{n}$, and, therefore, $a_{v\,r} = o$ when $v = n$.

Moreover it may be further observed, since by (13), (14), $a_r\, d_t = a_t\, d_r$, and consequently $b_{r+t} - b_t\, b_r = c_{r+t} - c_t\, c_r$, that k must be the same in $a_{v\,r}$ as in $d_{v\,r}$, and the same in $b_{v\,r}$ as in $c_{v\,r}$; but not necessarily the same in $a_{v\,r}$ or $d_{v\,r}$ as in $b_{v\,r}$ or $c_{v\,r}$. This, therefore, gives the number of functional roots n^2 for the same form of φ, and is another instance of deviation from the algebraic analogy. It arises from a similar cause to the preceding deviation, an anticipation in part, as it will presently appear, of the arbitrary function in the constants a_r, b_r, c_r.

For the sake of brevity, we shall adopt one common indeterminate integer which will enable us to give our final result something simpler.

$$\psi^{v\,r} x = \varphi^{-1}$$

$$\left\{ \frac{\sin\frac{vk\lambda}{n}}{\sin\frac{k\lambda}{n}} a_r + \frac{b_r + c_r}{2\cos\frac{k\lambda}{n}} \left\{ \cos\frac{vk\lambda}{n} + \frac{(b_r - c_r)\cos\frac{k\lambda}{n}\cdot\sin\frac{vk\lambda}{n}}{(b_r + c_r)\sin\frac{k\lambda}{n}} \right\} \varphi x \right\} \Bigg/ \left\{ \frac{b_r + c_r}{2\cos\frac{k\lambda}{n}} \cdot \left\{ \cos\frac{vk\lambda}{n} - \frac{(b_r - c_r)\cos\frac{k\lambda}{n}\cdot\sin\frac{vk\lambda}{n}}{(b_r + c_r)\sin\frac{k\lambda}{n}} \right\} - \frac{\left(b^{r2} - 2b_r c_r \cos\frac{2k\lambda}{n} + c_r^2\right)\sin\frac{vk\lambda}{n}}{2\,a_r\left(\cos\frac{2k\lambda}{n} + 1\right)\sin\frac{k\lambda}{n}} \varphi x \right\} \quad (21)^*$$

* This formula is in many instances better adapted for practice and printing under the following form.

$$\psi^{v\,r} x = \varphi^{-1}$$

$$\left\{ \sin\frac{vk\lambda}{n}\cdot\cos\frac{k\lambda}{n}\cdot 2\,a_r + \left\{ (b_r + c_r)\cos\frac{vk\lambda}{n}\cdot\sin\frac{k\lambda}{n} + (b_r - c_r)\cos\frac{k\lambda}{n}\cdot\sin\frac{vk\lambda}{n} \right\} \varphi x \right\} \Bigg/ \left\{ (b_r + c_r)\cos\frac{vk\lambda}{n}\cdot\sin\frac{k\lambda}{n} - (b_r - c_r)\cos\frac{k\lambda}{n}\cdot\sin\frac{vk\lambda}{n} - \frac{\left(b_r^2 - 2\,b_r c_r \cos\frac{2k\lambda}{n} + c_r^2\right)\sin\frac{vk\lambda}{n}\cdot\cos\frac{k\lambda}{n}}{a_r\left(\cos\frac{2k\lambda}{n} + 1\right)} \varphi x \right\}$$

which is produced from the other by merely multiplying the terms of the numerator and denominator by $\sin\frac{k\lambda}{n}\cdot\cos\frac{k\lambda}{n}$.

This is another general expression for determining $\psi^{v\,r}\,x$ from $\psi^n\,x = x$ whatever be the value of v, r, or n, rational, irrational, or imaginary. If we put $r = v = 1$, we easily deduce Mr. Horner's expression for $\psi\,x$, namely,

$$\psi\,x = \varphi^{-1}\left\{\frac{a + b\,\varphi\,x}{c - \dfrac{b^2 - 2\,b\,c\cos\dfrac{2\,k\,\lambda}{n} + c^2}{2\,a\left(\cos\dfrac{2\,k\,\lambda}{n} + 1\right)}\,\varphi\,x}\right\} \ldots\ldots\ldots (22)$$

which was investigated for positive integral values only of n, but which our general views show to be true for every value real or even imaginary.

Let us now apply these theorems to a few examples. Suppose first that $n = 2$, and $k = 1$; then $\cos\frac{2\,k\,\lambda}{n} = -1$, and the value for d becomes $\frac{(b + c)^2}{2\,a\,(\cos\,\lambda + 1)}$ which since the denominator vanishes must have $b = -\,c$. Differentiating the numerator and denominator twice with respect to c and λ respectively, we obtain $d = \frac{\delta\,c^2}{2\,a\,\delta\,\lambda^2}$ δ denoting differentiation. Therefore, because $\delta\,c$ and $\delta\,\lambda$ are mutually independent, this value of d may be any thing, and hence

$$\psi\,x = \varphi^{-1}\,\frac{a - b\,\varphi\,x}{b \pm d\,\varphi\,x} \ldots\ldots\ldots (23)$$

is the solution of $\psi^2\,x = x$. It is rather curious that this solution is obtained on the hypothesis of $k = \frac{n}{2}$ which Mr. Horner thinks cannot be, and obtained also from his own theorem. Again, let $n = 5$ and $k = 1$, then by Gauss's division of the circle $\cos\frac{2\,\lambda}{5} = \frac{\sqrt{5} - 1}{4}$, and therefore,

$$\psi\,x = \varphi^{-1}\left\{\frac{a + b\,\varphi\,x}{c - \dfrac{2\,b^2 - b\,c\,(\sqrt{5} - 1) + 2\,c^2}{a\,(\sqrt{5} + 3)}\,\varphi\,x}\right\}$$

which is the first and only solution I have seen of $\psi^5\,x = x$.

I shall not for brevity's sake stop to compute other cases of integral functions, but shall just give an instance, the first, I believe, that has been given, of the solution of a fractional function. Suppose $n = \frac{3}{4}$ and $k = 1$, then $\cos\frac{2\,k\,\lambda}{n} = \cos\frac{8\,\lambda}{3} = -\frac{1}{2}$, and, therefore, (22)

$$\psi x = \varphi^{-1} \frac{a + b\varphi x}{c - \frac{b^2 + bc + c^2}{a}\varphi x} \ldots\ldots\ldots (24)$$

which coincides with Mr. Babbage's solution of $\psi^3 x = x$. And because $\frac{3}{4} = 1 - \frac{1}{4}$ it is evident that $\psi^{-\frac{1}{4}} x$ ought to be the inverse of (24). Put therefore in (21) $r = 1$, $v = -\frac{1}{4}$, and of course making k as above $= 1$. From these data, we have

$$\sin \frac{vk\lambda}{n} = \sin. -\frac{\lambda}{3} = -\frac{\sqrt{3}}{2} \qquad \sin \frac{k\lambda}{n} = \sin \frac{4\lambda}{3} = -\frac{\sqrt{3}}{2} \qquad \cos \frac{2k\lambda}{n} = \cos \frac{8\lambda}{3} = \frac{1}{2}$$

$$\cos \frac{vk\lambda}{n} = \cos. -\frac{\lambda}{3} = \frac{1}{2} \qquad \cos \frac{k\lambda}{n} = \cos \frac{4\lambda}{3} = -\frac{1}{2}$$

Whence

$$\psi^{-\frac{1}{4}} x = \varphi^{-1} \frac{a + \frac{b+c}{2}\left\{-1 + \frac{b-c}{b+c}\right\}\varphi x}{\frac{b+c}{2}\left\{-1 - \frac{b-c}{b+c}\right\} - \frac{b^2 - bc + c^2}{3a}\varphi x} = \varphi^{-1} \frac{c\varphi x - a}{b + \frac{b^2 - bc + c^2}{3a}\varphi x}$$

which it may be easily shown is the inverse of (24), or equal to $\psi^{-1} x$.

This method of solution may, for the sake of distinction, be called the algebraic.

(To be continued.)

Article III.

Astronomical Observations, 1824.
By Col. Beaufoy, FRS.

Bushey Heath, near Stanmore.

Latitude 51° 37′ 44·3″ North. Longitude West in time 1′ 20·93″.

Oct. 2.	Immersion of Jupiter's second satellite.....	13h	50′	50″	Mean Time at Bushey.
		13	52	11	Mean Time at Greenwich.
Oct. 13.	Immersion of Jupiter's first satellite.....	17	01	08	Mean Time at Bushey.
		17	02	29	Mean Time at Greenwich.

Article IV.

On Fluoric Acid, and its most remarkable Combinations.

By Jac. Berzelius.*

I. *Compounds of Fluoric Acid with Electropositive Oxides, or with the Saline Bases properly so called.*

Fluoric acid, which may now be regarded either as a hydracid, or as an oxygen acid, is distinguished before every other substance by its great capacity of saturation, which, according to my earlier experiments, amounted to so much as 72·71, and, as will be subsequently demonstrated, is even somewhat higher than this quantity. With alkalies, it forms salts which are soluble in water, and which, when in a solid crystallized form, invariably possess either an acid or an alkaline reaction, as is the case with the borates, seleniates, arseniates, and phosphates. If a solution of a fluate be saturated until it possesses a perfectly neutral reaction, and if it be then committed to evaporation, there is always obtained, either an acid salt, while the supernatant liquid becomes alkaline, or the contrary. The fluates which I shall in this memoir style neutral, are those in which 100 parts of fluoric acid combine with a quantity of a base containing 74·72 parts of oxygen. Those containing an alkaline base, react as alkalies, and have a saline and weakly alkaline taste. Those whose base is an alkaline earth, are generally insoluble in water, and in that case possess no reaction whatever. Fluoric acid forms acid crystallizable salts with all the alkalies, which possess a strongly and purely acid taste, and whose solutions in water rapidily corrode glass. All the colourless crystallized fluates approach closely in refractive power to that of water: hence, when immersed in water, they appear semitransparent, and indeed their presence frequently remains unobserved, until the liquid is decanted. All the experiments alluded to in this memoir were made in vessels of platinum, except when the employment of glass vessels is expressly mentioned.

Fluate of Potash.—a. The *acid* fluate may be prepared by mixing with fluoric acid a quantity of potash insufficient to produce neutralization. During evaporation, a portion of the acid is dissipated, but the greater part crystallizes with the alkali on cooling. When obtained hastily in this manner, the salt forms an apparently solid mass, composed of broad plates, intersecting one another, and leaving numerous trapezoidal interstices, which

* Abstracted from Kongl. Vet. Acad. Handl. 1823, St. II. Want of room obliges us to omit a comprehensive historical sketch of the experiments and opinions of preceding inquirers.

are filled with liquid. If a saturated solution be abandoned to spontaneous evaporation, the salt gradually crystallizes in rectangular four-sided tables, with truncated lateral edges; resembling the form which we would produce by truncating two opposite apexes of an octahedron so deeply, as to convert it into a table. Sometimes also it crystallizes in cubes. It is very soluble in water, but its solubility is diminished in a remarkable degree by the presence of an excess of acid. When heated, it melts, gives off its excess of acid, and again becomes solid. The residue weighs 74·9 per cent. and consists of the neutral salt. When the salt is incorporated with six times its weight of oxide of lead, and ignited, there is expelled 11·6 per cent. of pure water, which, according as we consider fluoric acid to be an oxide or a hydracid, may be supposed either to have constituted a basis for the excess of acid, or to have been generated by the union of the hydrogen of the acid with the oxygen of the oxide of lead. The acid salt is composed, therefore, of an atom of fluate of potash and an atom of hydrous fluoric acid.

b. The neutral fluate of potash is most easily prepared by supersaturating bicarbonate of potash with fluoric acid, evaporating the solution to dryness, and expelling the excess of acid from the residue by ignition. It has a sharp saline taste, reacts strongly as an alkali, and is excessively deliquescent. It is very difficultly crystallizable; but if a solution be allowed to evaporate in a temperature between 95° and 104°, the salt may be obtained in crystals, which are sometimes cubes, and sometimes rectangular four-sided prisms. If a concentrated solution of this salt be neutralized with acetic acid, it may be evaporated to dryness without any of the acid separating; nor can the acetic acid be completely expelled, or the original salt regenerated, except by subjecting the residue to ignition. The solution of this compound salt is strictly neutral while in a state of concentration; but if it be largely diluted with water, it acquires a strongly acid reaction, and the acetic acid becomes at the same time disengaged. I consider this property to be very remarkable. A solution of this salt, even when cold, slowly attacks glass, and destroys its polish. This property, for which I can conceive no satisfactory explanation, at first appeared to me to be occasioned by a tendency in the neutral fluate to combine with an excess of base. To determine, therefore, if it be possible to produce a sub-fluate, I mixed a concentrated solution of the neutral salt with an alcoholic solution of potash; but I could not perceive that any alteration was produced on its properties by this addition. I then fused a mixture of the neutral salt and subcarbonate of potash; but no carbonic acid was expelled, nor did the mixture sustain any diminution of weight. Hence it appears that a subsalt cannot be easily formed, so long at least

as the excess of potash is in a situation to combine either with carbonic acid or with water. Fluate of potash in a red heat dissolves silica, and forms with it a transparent mass; and no silicated fluoric acid is disengaged, in temperatures below that necessary to melt glass. The mass on cooling has a white porcelaneous aspect, and water extracts from it a deliquescent salt.

Fluate of Soda.—a. The *acid* fluate may be crystallized in transparent rhomboids. It possesses a sharp and purely acid taste, and is but sparingly soluble in cold water. It is composed of an atom of fluate of soda, and an atom of hydrous fluoric acid.

b. The neutral fluate of soda is most economically prepared by mixing 100 parts of dry silicated fluate of soda and 112 parts of anhydrous subcarbonate of soda with as much water as will form with them a thin pap, and boiling the whole until it ceases to effervesce. After about an hour, the mixture concretes to a solid mass: this must be reduced to powder, and again boiled in water, so long as it effervesces. By this means we obtain a mixture of fluate of soda and silica: the former is to be separated by repeatedly washing the insoluble portion with water.* The solution, when slowly evaporated, deposits the salt in crystals. But with whatever precautions the preparation of this salt may be conducted, a small quantity of the silica invariably passes into solution: hence after the greater portion of the fluate of soda has crystallized, the liquid becomes opalescent, being unable to retain the whole of the uncombined silica in solution. It must be evaporated to dryness, and the residue ignited, in order to render this silica insoluble. If any of the double fluate had escaped decomposition at the commencement of the process, it forms a part of this dry mass, and its excess of acid is expelled during the ignition: the dissipation of the last portions may be greatly facilitated by introducing into the crucible, while red-hot, a bit of carbonate of ammonia, and immediately after covering it up with its lid.

Fluate of soda crystallizes in cubes and regular octahedrons: the crystals are transparent, and have sometimes the lustre of mother of pearl when viewed with reflected light. It is always obtained in octahedrons, when the solution contains carbonate of soda. It is remarkable that the fluates of potash and soda are isomorphous with the muriates of the same bases (chloride of potassium and chloride of sodium), and also, so far at least as can be concluded from what has been already ascertained, with the analogous compounds formed by iodine. This salt is less fusible than glass. Water dissolves it very slowly; and its solu-

* The object of this process is to prevent the silicate from gelatinizing; the gelatinous silica resulting from the decomposition of fluosilicates being sensibly soluble in water.

bility is not in the least degree augmented by an elevation of temperature. At the temperature of 61°, 100 parts of water are capable of retaining in solution four parts of the salt. It is almost completely insoluble in alcohol.

Fluate of Lithia.—a. The *acid* fluate is a crystallizable salt, but little soluble in water. *b.* The *neutral* fluate dissolves with great difficulty in water, resembling in the degree of its solubility the carbonate of lithia. The solution is converted by evaporation into a white mealy-looking mass, composed of opaque granules.

Fluate of Ammonia.—a. The *acid* fluate is a deliquescent salt, which may be obtained in the form of granular crystals by allowing a solution to evaporate in a temperature about 100°. *b.* The *neutral* fluate cannot be procured by the humid way otherwise than dissolved in water; because when a neutralized solution is exposed to the open air, even in the ordinary temperatures, it gradually loses a portion of its ammonia, and is converted into the acid salt. It may, however, be easily prepared in the dry way by the following process. Mix in a platinum crucible 1 part of sal ammoniac and 2¼ parts of fluate of soda, both thoroughly pulverised, and in a state of complete dryness; and cover the crucible with an inverted lid, filled with water, in order that it may be preserved sufficiently cool. Let a gentle heat be now applied to the crucible by means of a spirit-lamp: the fluate of ammonia will speedily volatilize without the slightest admixture of sal ammoniac, and will condense upon the lid in a mass of small prisms. This salt is permanent in the air: it is copiously soluble in water, but only slightly so in alcohol. When heated, it melts before it begins to sublime. In glass vessels it cannot be preserved even when dry, without corroding them. Ammonia, in the gaseous state, is rapidly absorbed by it, and the product is a *subsalt*, which is decomposed by sublimation.

Fluate of barytes is most easily obtained by digesting newly precipitated carbonate of barytes in an excess of fluoric acid: the carbonate is gradually converted into fluate of barytes, which remains undissolved. This salt is only very slightly soluble in water, or in an excess of fluoric acid. It dissolves abundantly in muriatic acid, and ammonia precipitates from the solution a chemical compound of fluate and muriate of barytes. The same compound may be formed by mixing solutions of fluate of soda and muriate of barytes. It is much more soluble in water than fluate of barytes, and by evaporating the solution, may be recovered in granular crystals. Repeated washings decompose it partially; the residue upon the filter, however, when dissolved in water, retains to the last the property of precipitating nitrate of silver. I found it by analysis to be anhydrous, and to be composed of an atom of muriate and an atom of fluate of barytes.

It is, therefore, a double salt with two acids, or at least an analogous compound.

I did not succeed in forming either a super or a subfluate of barytes.

Fluate of strontian may be prepared in the same manner as the preceding, which it closely resembles in its inconsiderable solubility in water, or an excess of fluoric acid.

Fluate of Lime.—The best method of obtaining this salt artificially is to digest newly precipitated carbonate of lime in an excess of fluoric acid. When thus prepared, it constitutes a granular powder, which may be easily washed. When we attempt to prepare it by mixing solutions of a neutral salt of lime and a neutral fluate, it always precipitates as a jelly, which it is impossible to wash, because it speedily stops up the pores of the filter; and it retains this gelatinous form even after having been evaporated to dryness, and digested in water. Its deposition is somewhat promoted by the addition of ammonia. Acids dissolve it slightly when newly formed, and the addition of an alkali precipitates it from the solution unaltered.

Sulphuric acid incorporated with finely pounded fluate of lime, whether prepared artificially or the native spar, converts it into a transparent syrupy mass, which may be drawn into threads; but no expulsion of acid takes place until the mixture is heated to a temperature of about 100°. The addition of water to the liquid renders it opaque, and causes the disengagement of fluoric acid. Concentrated nitric and muriatic acids render fluor spar transparent in a similar manner, but the liquid is not so glutinous, and the mineral is precipitated unaltered by water. If the fluor spar contains the slightest admixture of silica, it instantly effervesces when mixed with sulphuric acid.

Fluate of lime appears to be isomorphous with the fluates of potash and soda.

Fluate of magnesia is insoluble in water, and in an excess of fluoric acid.

Fluate of glucina is difficultly soluble in water; but a solution saturated in a temperature of 212° deposits on cooling minute crystalline scales, which possess an astringent taste, and redden moistened litmus paper. Neither this nor the preceding salt is decomposed by ignition.

Fluate of yttria is nearly insoluble, even in an excess of acid; before being ignited, however, it has an astringent taste, and reddens moistened litmus paper.

Fluate of alumina is very soluble in water. A solution of it when concentrated forms a clear uncrystallizable syrup, and when evaporated to dryness, it leaves the salt in the state of a transparent, yellowish coloured, friable mass, resembling gum arabic. Thus prepared it is tasteless, and when put into water, appears at first to be insoluble, but in the course of about an hour,

it is completely dissolved, and it dissolves still more rapidly in boiling water. A *subfluate* may be obtained either by igniting the neutral fluate, or by digesting it in water along with hydrate of alumina.

Fluate of zirconia is very soluble in water. The solution when evaporated deposits crystals, which when digested in water are decomposed into an acid salt which passes into solution, and a subsalt which remains undissolved.

Fluate of Oxidule of Manganese.—A crystalline powder, permanent in a red heat, and soluble in water, with the assistance of an excess of acid.

Fluate of Oxide of Manganese.—A solution of the native hydrated oxide in fluoric acid has an intense red colour, and by spontaneous evaporation deposits this salt in transparent prismatic crystals, which are dark brown coloured when large, but ruby red when minute. In a minimum of water it dissolves without decomposition; but if the solution be heated or diluted, a subsalt precipitates, and an acid salt remains dissolved.

Fluate of oxidule of iron may be prepared by dissolving the metal, with the aid of a gentle heat, in fluoric acid; the salt gradually separates in small crystals, which appear to be rectangular four-sided tables. When first obtained, it is white, but acquires a yellowish shade on exposure to the air. Water dissolves it sparingly. Ignited, it gives off water of crystallization, and a small quantity of acid: after this, it becomes red coloured, and sustains no further decomposition.

Fluate of oxide of iron is obtained in the form of a crystallized pale flesh coloured powder, by dissolving the hydrated peroxide in fluoric acid, and evaporating. It has a sweet and astringent taste. Water dissolves it slowly, but completely; the solution is colourless even when concentrated, and ammonia does not develop in it a deep red colour, as happens with solutions of the ordinary salts of oxide of iron. Ammonia added in excess precipitates from this solution a *subfluate.*

Fluate of oxide of zinc forms small white opaque crystals, which are difficultly soluble in water, but are copiously dissolved by ammonia.

Fluate of oxide of cadmium is obtained by evaporating a solution in the state of a white crust, which exhibits no indications of a regular crystallization.

Fluates of the Oxides of Cobalt, Nickel, and Copper.—The colour of the first is rose red; of the second light green; of the third light blue; in other respects their properties are so closely similar that a description of one may be accurately applied to the rest. They may be prepared by mixing the carbonated oxide with fluoric acid: it dissolves with effervescence, and the fluate is soon after precipitated in the form of a heavy powder. If an excess of carbonate be added, and especially if heat be at

the same time applied, the fluate thus formed is gradually converted into a subfluate. The neutral salts are only sparingly soluble in water. A small quantity of water dissolves them unaltered; but an excess decomposes them into salts which are held in solution by the disengaged acid, and insoluble *subsalts*. The *subfluates* of nickel and copper have a pale green colour. The fluate of copper, when decomposed by sulphuric acid, yields 116 per cent. of sulphate of copper, and when ignited with ten times its weight of oxide of lead, gives off 26·3 p. c. of water. Hence it is a neutral fluate of copper combined with four atoms of water. The insoluble salt obtained by boiling the preceding in water yields, by a similar mode of analysis, 158·2 p. c. of sulphate of copper and 9·3 p. c. of water. It is, therefore, a subsalt, composed of two atoms of peroxide of copper, one atom of fluoric acid, and two atoms of water.*

Fluate of oxidule of copper may be formed by treating the hydrate with fluoric acid: it instantly becomes red, and does not dissolve in an excess of the acid. It must be washed with alcohol. When ignited it assumes a dark cinnabar red colour. When exposed in a moistened state to the air, it at first becomes yellow, in consequence of half the base forming with the acid neutral fluate of oxidule, while the other half forms hydrate of oxidule; after some time it becomes green, and is wholly converted into the subfluate of *oxide* of copper. This salt is soluble in muriatic acid: the solution is black, and water precipitates the salt in the form of a pale rose red coloured powder.

Fluates of oxidule and of oxide of cerium correspond in most of their characters with the fluate of yttria. Both occur native. The fluate of oxide of cerium has a yellow colour.

Fluate of lead is slightly soluble in water, but not in an excess of fluoric acid. It melts in a low heat, and after fusion appears yellow. Ammonia converts it very readily into a subsalt. This *subfluate* is soluble in water; when the solution is exposed for some time to the air, it becomes turbid, and a crust is formed upon its surface, composed of carbonate and fluate of lead. If a solution of fluate of soda be mixed with a boiling hot solution of muriate of lead, a double salt precipitates, which is to a small extent dissolved, but is not in the least degree decomposed by washing. This salt is white and pulverulent, and may be fused without losing either acid or water. I found it by analysis to be composed of an atom of fluate of lead and an atom of muriate or chloride of lead.

Fluate of oxide of chromium may be prepared by dissolving

* Berzelius considers the atomic weights of oxygen, fluoric acid, oxide of copper, and water, to be 100, 270·34, 991·39, and 112·4354. If we represent them by the numbers 1, 1·3517, 5, and 1·125, the neutral salt will be composed of one atom of acid, one of base, and two of water; and the subsalt, of one atom of acid, two of base, and one of water.

the newly precipitated oxide in fluoric acid. The solution has a rose red colour, and affords a pale rose red coloured salt by evaporation.

Fluate of Oxidule.—A green crystalline mass, easily soluble in water.

Fluate of antimony is very soluble in water, and may be obtained in colourless crystals by spontaneous evaporation. Its taste resembles that of tartar emetic.

Fluate of oxidule of tin is easily soluble in water, and crystallizes in white, shining, opaque prisms. It becomes rapidly peroxidized when exposed to the air.

Fluate of Oxide of Uranium.—A white pulverulent salt, readily soluble in water, and affording a yellow coloured solution.

Fluate of Silver.—A very soluble deliquescent salt, whose properties have been already sufficiently described by Gay-Lussac and Thenard.

Fluate of oxide of mercury crystallizes in dark yellow coloured prisms. Water decomposes these crystals, and a portion of the oxide remains undissolved, in the state of a beautiful yellow *subsalt*, resembling turpeth mineral. Ignited in a platinum vessel, the neutral salt sublimes, and forms light yellow coloured crystals; but a portion of it at the same time undergoes decomposition, and the platinum is corroded. In a glass retort it is instantly decomposed, and there distils over a mixture of silicated fluoric acid gas and metallic mercury. Ammonia converts this salt into a white coloured double salt, containing an excess of base.

Fluate of Oxidule of Mercury.—I could not succeed in preparing, either by distilling the fluate of oxide with mercury by treating calomel with a solution of fluate of soda, or by evaporating over mercury a mixture of fluoric acid and a solution of nitrate of oxidule of mercury. In the last experiment, the nitrate of mercury reappeared in crystals, and the fluoric acid did not produce the slightest decomposition.

Fluate of Oxide of Platinum.—It is generally considered difficult to combine oxide of platinum with any other acid than the muriatic: this object may however be easily effected by dissolving in water a quantity of the salt of potash whose acid we wish to combine with the oxide, and by mixing the solution with muriate of platinum so long as it continues to produce a precipitate. A small quantity of the muriate of platinum and potash remains in solution, but by evaporating the clear liquid, the whole of this may be made to separate in crystals. I had recourse to this method in preparing the fluate of platinum. The clear liquid was evaporated to dryness, and the residue was treated with alcohol, which dissolved the fluate, but left the

double muriate untouched. The alcoholic solution mixed with water, and abandoned to spontaneous evaporation, was gradually converted into a bright yellow coloured uncrystallized mass. This salt forms a double salt with fluate of potash.

Saturating Capacity of Fluoric Acid.—From some experiments made, on a former occasion, with the utmost attention to accuracy, I concluded that 100 parts of pure fluor spar, when decomposed by sulphuric acid, yield 173·63 parts of sulphate of lime. I had still in my possession the specimen which had furnished materials for the preceding determination, and on repeating the analysis with it, I obtained precisely the same result; but being now better apprized of the circumstance that fluoric and phosphoric acids almost invariably accompany one another in the mineral kingdom, I was induced to examine the specimen more narrowly, and found that it was in fact contaminated with half a per cent of phosphate of lime mixed with some phosphate of oxidule of manganese. I ascertained the presence of these substances by digesting the gypsum in muriatic acid, precipitating by ammonia, and treating the precipitate with water so long as any sulphate of lime passed into solution: the phosphates remained undissolved, and were instantly recognized by their behaviour before the blowpipe. The unavoidable errors attendant upon this method of analysis, however, rendered it impossible for me to determine the quantity of the phosphates with perfect precision: I was, therefore, unable to deduce from the experiment the exact saturating capacity of fluoric acid. On this account, I resolved to repeat the analysis with a quantity of artificial fluate of lime, prepared with the utmost precautions to ensure the absence of every foreign admixture. The acid which I employed for this purpose was prepared from pure fluor spar, and distilled sulphuric acid, in a distillatory apparatus of platinum; and was received in distilled water, until the liquid began to smoke: in order still more to obviate the possibility of the presence of silica, the first fourth of the acid which distilled over was kept separate. This acid was mixed with a quantity of carbonate of lime insufficient to saturate it completely; and the fluate of lime thus formed was washed in a funnel of platinum. On the supposition that the salt might still retain some silica, I mixed it with cold concentrated muriatic acid, and at the conclusion of an hour, washed it thoroughly with water. Had the slightest trace of silica been present, it would have been dissolved out by this treatment, in the form of a double salt with the fluoric acid and lime. If fluate of lime, after ignition, can be moistened with fluoric acid without sustaining any elevation of temperature, it may be regarded as absolutely free from silica; for if the smallest quantity of silica be present, this treatment always occasions a sensible evolution of heat. Of all the fluates which I have examined, the fluate of lime was the

only one which I succeeded in freeing completely from the last portions of silica.

100 parts of the fluate of lime thus prepared and purified were digested in the state of an impalpable powder in concentrated sulphuric acid, and after a considerable interval, the mixture was evaporated to dryness and ignited. In different experiments, I obtained 174·9, 175, and 175·12 parts of sulphate of lime. Of these numbers, I consider the middle one, 175, to be the most accurate. According to this experiment, fluate of lime is composed of

Fluoric acid.	27·3225	100
Lime.	72·6775	266

And the atomic weight of fluoric acid is 270·34, instead of 275, the number which I had previously given in my tables. It may, perhaps, be objected that the number 270·34 is not an equimultiple of 6·25, which has been considered as the true atomic weight of hydrogen, and which many philosophers are of opinion ought to divide without a remainder the atomic weights of all other substances. I do not think that any argument of general application can be deduced from the circumstance that the atomic weight of oxygen is divisible without a remainder by this number, and that the atomic weights of several other substances approach very nearly to equimultiples of 6·25.* This number is so small, when compared with the atomic weights of most other substances, that it is generally exceeded by the unavoidable errors of experiment; consequently, more decisive proofs than any hitherto obtained are required from this source, before the question can be finally answered. We are as yet acquainted with no physical circumstances which render this simplicity of relation a necessary law of nature, and until this be proved, we must continue to regard the supposed system of multiples as very possibly nothing else than a seducing hypothesis. Be that as it may, the former atomic weight of fluoric acid, 275, which is an equimultiple by 44 of 6·25, is unquestionably too high. Those chemists who will be disposed to correct the new atomic weight in conformity with the supposition alluded to above, will make it 268·75, a number which certainly differs very little from 270·34, but is in so far arbitrary, that it does not result from any direct experiment.

Double Salts of Fluoric Acid with two Saline Bases.—The acid fluates of the alkaline bases possess a remarkable tendency to combine with a different base, in the proportion requisite to

* From the experiments which I made in company with M. Dulong on the composition of water and on the specific gravity of hydrogen gas, it follows that the atomic weight of hydrogen is 6·2171. This number I have adopted in my tables, and it is obvious that a very inconsiderable deficiency in the number 6·25 would overthrow the whole hypothesis.

saturate their excess of acid; nevertheless these combinations cannot be effected in the humid way with all the saline bases, for the mixture, in some instances, separates either by precipitation, or by crystallization, into two distinct fluates. The fluates of potash and soda do not combine, and if either of their acid salts be saturated with ammonia, the whole of that alkali is gradually dissipated, even when the evaporation is performed in the ordinary atmospheric temperatures, and we again obtain the acid salts unaltered.

One of the most interesting of these double salts is unquestionably the combination of *fluate of soda and fluate of alumina*, which occurs in the mineral kingdom, and is known to mineralogists by the name of *cryolite*. It may also be prepared artificially. Thus if a solution of acid fluate of soda be cautiously mixed with hydrate of alumina until it loses its acid reaction, the liquid becomes little more than pure water, and when evaporated leaves a mere film of the double salt, which had remained in solution. As both the fluate of soda and fluate of alumina are readily soluble in water, this experiment of itself demonstrates that in the double fluate which precipitates the proportion of its constituent salts is such that both contain the same quantity of acid; otherwise an excess of one or other of the two salts would have remained in solution. This compound may also be formed by digesting hydrate of alumina in a solution of neutral fluate of soda. If the experiment be made in a close vessel, the liquid, when the decomposition is effected, possesses an alkaline and caustic taste; if under free exposure to the atmosphere, the liquid attracts carbonic acid, and is found to be a solution of carbonate of soda. During the digestion, the alumina rapidly assumes the appearance of a semitransparent mass; but when dried, it loses the whole of its gelatinous aspect, and becomes white and pulverulent.

To satisfy myself of the identity of these double salts with the one formed by nature, I subjected a quantity of cryolite to analysis. When ignited, it gives off neither chemically combined water, nor silicated fluoric acid. 100 parts were digested with sulphuric acid so long as fluoric acid continued to escape; the mixture was then evaporated, until the greater portion of the excess of sulphuric acid was dissipated. The saline mass being redissolved in water, and the solution decomposed by ammonia, gave 24·4 parts of alumina. The filtered liquid was now evaporated to dryness, and the residue was cautiously ignited, in order to free the sulphate of soda from sulphate of ammonia and excess of acid. The salt after fusion weighed 101 parts, equivalent to 44·25 parts of soda. Consequently 100 parts of the mineral are composed of

Fluoric acid (including loss)	31·35
Soda	44·25
Alumina	24·40
	100·00

The two bases, therefore, contain equal quantities of oxygen, and saturate equal quantities of fluoric acid.

A similar compound may be obtained by treating the acid fluate of *potash* with alumina; but it seems to depend upon weaker affinities than the preceding, for a dilute solution of the salt dissolves the hydrate without becoming turbid, and if the hydrate be employed in sufficient quantity to supersaturate the acid, the liquid filtered from the mixture is found to contain a large portion of neutral fluate of potash. The insoluble double salt may however be obtained in a state of purity, either by boiling the mixture, or by evaporating the liquid in contact with hydrate of alumina. Like the preceding it is semitransparent while moist, but white and pulverulent when in a state of dryness. Gay-Lussac and Thenard have stated that a solution of alum is precipitated by fluate of potash, but this precipitate can be made to appear instantaneously only by reversing their experiment; for when a solution of fluate of potash is added gradually to a solution of alum, it does not occasion the slightest turbidness until its quantity is sufficient to form with the alumina the insoluble double fluate. They mistook, therefore, this double salt for the simple fluate of alumina. In the analysis of minerals which contain at once alumina and fluoric acid, and whose decomposition has been effected by potash or soda, this combination of the two fluates is always precipitated along with the alumina; and when this precipitate is violently ignited, the alumina displaces the fluoric acid from its union with potash, and there is obtained the usual sublimate of silica mixed with a little alumina around the lid of the crucible. The silica proceeds from a small quantity which had been precipitated along with the alumina, and both it and that earth are separated from the fluoric acid by the water which is formed by the hydrogen of the combustible, and are deposited around that part of the edge of the crucible, along which the gases make their escape.

A *double fluate of ammonia and alumina* may also be prepared by digesting hydrate of alumina either in the acid, or in the neutral fluate of ammonia. While still moist it has a semitransparent appearance, like gelatinous silica, but is converted into a white powder by drying. When ignited, it gives off first ammonia, then acid fluate of ammonia, and subfluate of alumina remains. It dissolves to a certain extent in pure water, but not in the liquid from which it is precipitated, nor in ammonia. The double salts of soda and potash are also soluble in water, but to a much smaller extent; indeed the latter may be washed with-

out any sensible loss. That *lithia* forms an insoluble double salt with fluoric acid and alumina is already well known; for the mineral called amblygonite consists of a compound of this nature mixed with a double subphosphate of the same bases.

Fluate of alumina possesses a similar tendency to form double salts with the metallic fluates. I have examined its compounds with the fluates of the oxides of copper, nickel, and zinc. They are in general more soluble in water than the simple metallic fluates, and, contrary to what takes place with the latter, they pass into solution without undergoing decomposition; nevertheless, like the fluate of alumina, after they have been once reduced to a solid form, a long time elapses before they can be again redissolved by cold water. The double salt of copper is pale bluish green, that of nickel pale apple green, that of zinc colourless; and they may be all obtained crystallized in long prismatic needles by spontaneous evaporation. Ammonia precipitates from the aqueous solution an aluminate of the oxide. I have not entered more minutely into the investigation of these compounds than was necessary to demonstrate the remarkable tendency of fluoric acid when in union with oxides which act not only very feebly as acids, to form double salts with the fluates of a different class of oxides, which invariably possess the characters of bases when combined either with the electronegative oxides, or with the weaker acids. Other oxides also, which, like alumina, contain three atoms of oxygen, as, for example, oxidule of chromium, oxide of iron, yield similar series of double salts, which are in general either insoluble, or very difficultly soluble in water. In most cases these compounds do not precipitate until the mixed solutions are heated. The double salts formed by fluate of oxidule of chromium with the alkaline fluates are grass green pulverulent precipitates; those of oxide of iron are pale straw yellow, or almost colourless.

The alkaline fluates containing an excess of acid resemble the acid sulphates, tartrates, and oxalates of potash or soda, in the great readiness with which they combine with other bases, particularly metallic oxides, in order to form double salts. I have examined the double salts which they form with the oxides of iron, copper, nickel, cobalt, manganese, and zinc. They are in general difficultly soluble in water, and possess only a faint shade of the colour of their metallic oxide. The alkaline fluates form double salts also with the fluate of oxide of platinum. They crystallize only from a very concentrated solution, and the crystals have a dark brown colour, more intense even than that of the simple salts of platinum. They are insoluble in alcohol. The fluate of uranium forms double fluates with the utmost facility: most of them dissolve in water, and those containing an alkaline fluate shoot in yellow coloured crystals. Oxide of antimony also forms a series of double salts, which are crystalli-

zable, but are more difficultly soluble than those of oxide of uranium.

The occasional differences observable between the preceding and Gay-Lussac and Thenard's descriptions arise principally from these chemists having formed some of their fluates by double decomposition, by which they obtained double in place of simple salts.

(*To be continued.*)

Article V.

Remarks on Mr. Battley's Method of preparing Morphia. By W. A. South, Esq.

(To the Editors of the *Annals of Philosophy*.)

GENTLEMEN, *Aug.* 10, 1824.

In the Medico-Chirurgical Review for last June, I find a paper from Mr. Battley, professing to show "the constituents of opium." Mr. Battley states that "twenty-six pounds (avoirdupois) of dry opium imparted to distilled water twenty-three pounds" (rather more than usual, I think), "leaving a residuum weighing three pounds when dried; this residuum, or *refuse*, I apprehend to contain *the morphium*, and to the exposition of *this fact* my present and immediate purpose is confined." The fair inference to be drawn from this statement, the definite article *the* being used, I conceive to be, that *the morphium* is contained in the residue alone. How far this assertion is correct I will leave those to determine who have obtained morphia from the formulæ of Robiquet, Choulant, Thomson, and others, when the aqueous infusion alone was ordered, and from which it would appear they were successful in obtaining the desired salt. That Mr. Battley might obtain morphia from the residuum of the opium after it had been submitted to the usual processes given for that purpose, I am perfectly aware, and as far as I can judge, he might have added, in a greater state of purity.

"The residuum of three pounds having been macerated in acetic acid produced, on the addition of ammonia in excess, a precipitate amounting to 38 drams 20 grains when dried, from which Mr. B. obtained morphia at the rate of 29 grains per dram. Mr. B. then "proceeds to show a similar result from the residual matter of tincture of opium, tincture bottoms." This appears to be at the rate of 28 grains per dram of precipitate. So far Mr. B. seems to have been particularly fortunate, in showing "a similar result;" but coupling it with the concluding paragraph of his paper, viz. "I must not now conclude, without stating that laudanum, tincture of opium, does not con-

tain any, or if any, only a very small portion of morphium," he is I think particularly unfortunate. If Mr. Battley mean to say that the distilled water in which he had infused the opium did not contain any morphia, how does it happen that so many have obtained it from such a solution? and if he admit that it does contain morphia, where is the corresponding quantity from the opium infused in spirit, if it be not held in solution by the spirit? Unless Mr. Battley can state by what means the morphia can make its exit, I must consider that his experiments prove directly the reverse of his conclusions.

W. A. South.

Article VI.

Experiments on the Analysis of some of the Aëriform Compounds of Nitrogen. By William Henry, MD. FRS. &c. &c.

(*Concluded from* p. 303.)

2.—*Of the Analysis of Nitric Acid.*

The evidence of the composition of nitric acid, on which the view, now most commonly taken of its constitution, is founded, is derived almost entirely from synthetic experiments. Sir H. Davy long ago stated,* that 4 in volume of nitrous gas and 2 of oxygen gas, condensed in water, absorb 1 in volume of oxygen to become nitric acid. But 4 in volume of nitrous gas being equivalent to 2 of nitrogen and 2 of oxygen, the whole oxygen in nitric acid will be 5 volumes to 2 of nitrogen, or 2·5 volumes to one volume. The smallest proportion of nitrous gas found by Mr. Dalton to unite with oxygen gas, viz. 13 nitrous to 10 oxygen, gives the ratio in volume of nitrogen to oxygen, in nitric acid, as 1 to 2·53.† M. Gay-Lussac also determined by the test of the red sulphate of manganese, which is deprived of colour by the nitrous but not by the nitric acid, that the latter acid only is generated when 134 measures of nitrous gas are made to combine with 100 of oxygen, proportions which indicate almost exactly 1 volume of nitrogen and 2·5 volumes of oxygen in nitric acid.‡

But though the synthetic proofs rest on such high authorities, and all tend to the same point, yet it is desirable to confirm evidence of this nature by that of analysis, whenever it can be obtained; and the object appeared to M. Gay-Lussac sufficiently important to induce him to seek for this additional proof in two different ways, viz. by the decomposition of nitrate of

* Elements of Chemical Philosophy, p. 264.
† New System, p. 328, 364.
‡ Ann. de Chim. et de Phys. i. 404.

lead and also of nitrate of baryta, each without addition, at high temperatures. The results, however, for reasons which he has stated (same work, p. 405) were not satisfactory. On again reading his memoir, it occurred to me that a more complete decomposition of nitrate of baryta would probably be obtained by exposing it to a sufficient heat, in a state of intimate mixture with charcoal; and that the elements of the nitric acid would be evolved in the state of carbonic acid and nitrogen gases, products which admit of being easily and exactly separated from each other.

In my first trials of this process, I failed from the employment of too little charcoal, in consequence of which much nitrous acid vapour passed over, and acted upon the mercury over which the gases were collected. After repeating the operation several times, with various proportions of the materials, I found that by using at least 1 part of charcoal to $2\frac{1}{2}$ of the nitrate of baryta, nitrous acid vapour was no longer evolved. In an experiment made with great care, the barytic salt was finely pulverised, and exposed for a whole day, with surfaces frequently renewed, to a temperature of 212° Fahr. It was then mixed with the powdered charcoal, which had been recently ignited in a close vessel, to expel any moisture it might contain, and which was still hot; and a portion of quartz in very small grains, equal in weight to the nitrate, was added to prevent the deflagration from being too rapid. The mixture was put into a green glass tube of the diameter of a common quill, into the upper part of which, before bending it so that it might pass beneath the mercury of the trough, a known weight of iron wire coiled into a spiral form was introduced. Under this part of the tube a double row of burning spirit lamps with flat wicks was placed; and when the iron wire appeared red hot, the mixture at the bottom of the tube was heated by another lamp, at first moderately to expel any moisture, that might have been absorbed from the air while the tube was being filled, and then more strongly so as to set the mixture on fire. By slowly moving the flame of the lamp under that part of the tube which contained the mixture, from above downwards, the combustion spread gradually through the whole, and the gaseous products were not more rapidly evolved than was consistent with their being wholly collected. They proved to be more complicated than I expected; for not only carbonic acid and nitrogen were obtained, but nitrous gas, carbonic oxide, and a very small quantity of hydrogen, the last of which would indicate the presence of water in the proportion of about 0·7 of a grain to 100 of the nitrate and the materials added to it.

In the tube there remained, besides charcoal, carbonate of baryta, with a very small quantity of that earth in its pure state, but no undecomposed nitrate. After separating the pure baryta

by boiling water, the carbonate was dissolved out of the excess of charcoal by muriatic acid; the solution decomposed by sulphate of soda; and, from the quantity of sulphate of baryta, its equivalent in carbonate, and the quantity of carbonic acid in the latter compound, were determined.

The analyses of the mixture of gases was made with the greatest care, and was thrice repeated. Reckoning up the oxygen contained in all the different products, and the nitrogen both free and in the nitrous gas, the volume of the latter was found to be to that of the former as 7·9 to 19·85, or as 1 to 2·51; thereby fully confirming that view of the proportion of the elements of nitric acid, which had previously been derived from synthetic experiments.

If then nitrous oxide be taken as the binary combination, in which the elements, nitrogen and oxygen, exist atom to atom singly, two volumes of nitrogen will contain the same number of ultimate particles or atoms as one volume of oxygen. And imagining the smallest possible volume of each of those gases, or a volume containing only a single atom, the ultimate volume of nitrogen will be double the ultimate volume of oxygen. Two measurable volumes of nitrogen, when chemically united with one of oxygen, or with two, three, or more volumes, will afford compounds of nitrogen and oxygen, in which the atoms will bear the proportion of one to one, or one to two, to three, or to more atoms. And as two volumes of nitrogen are, in nitric acid, combined with five of oxygen, that acid is justly considered as constituted of one atom of nitrogen, the relative weight of which is 14, and five atoms of oxygen weighing together 40.

3.—*Analysis of Ammonia.*

Another combination of nitrogen, the exact analysis of which is of great importance, from the connection of the results with the law of volumes, as well as with the atomic system, is that into which it enters with hydrogen. Only one compound of those two elements, viz. ammonia, has yet been discovered, the decomposition of which, when existing as a permanent gas over mercury, may, as is well known, be effected by subjecting it to a long continued succession of electrical sparks, or of discharges from a Leyden jar. This method, originally discovered by Dr. Priestley, has been employed by the late Count Berthollet, by Sir H. Davy, by Mr. Dalton, and by myself, with a view to the accurate analysis of the gas. The process, however, being one into which sources of error may easily be introduced, there is not so perfect an agreement, as might have been wished, among the results of different observers. Without entering into a detail of these discrepancies, or a statement of their causes, it may be sufficient to observe that the view of

the constitution of ammonia, taken by M. Gay-Lussac, represents it as consisting of 1 volume of nitrogen and 3 volumes of hydrogen condensed into the space of 2 volumes.

In order to satisfy myself on a point, the determination of which is so essential to a just view of the atomic constitution of the compounds of nitrogen, I have lately made fresh experiments on the decomposition of ammonia by electricity, using every precaution that occurred to me as likely to insure the accuracy of the results. The gas was collected over recently boiled and dry mercury, and was transferred for decomposition into graduated tubes, filled with mercury, which had been heated in the same tubes and still remained hot. To prevent any ammoniacal gas from lodging beneath the surface of the quicksilver in the tube, the flame of a spirit lamp was passed slowly along the part containing mercury, a precaution which was shown not to have been unnecessary by the ascent of a few bubbles of gas.

In four experiments, conducted with a degree of caution, to which I am not aware that any thing could have been added, the volume of the ammoniacal gas was fully doubled. In the first, 44 measures became 88 +; in the second, 157 became 320; in the third, 60 became 122; and in the fourth, 120 became 240. The evolved gases, carefully analyzed by combustion with oxygen, were found in each case to consist of 1 volume of nitrogen and 3 volumes of hydrogen. I repeated, also, with the greatest attention, a process for analyzing ammonia, which, with various other methods capable of being more quickly executed than that of electrical analysis, I have described in the Philosophical Transactions for 1809. It consists in firing, by the electric spark, a mixture of the alkaline gas with nitrous oxide, the latter being employed in rather less proportion than would be necessary for perfect decomposition, in order to prevent the formation of nitrous acid vapour, which is always generated when the nitrous oxide is in excess. For example, 10 measures of ammonia were deflagrated with 12 or 13 of nitrous oxide, the full proportion of the latter being, if pure, 15 measures. All the oxygen of the nitrous oxide was transferred to the hydrogen of the ammonia, water was formed, and the whole nitrogen of both gases remained as the aëriform product, mixed with a small quantity of hydrogen gas, for the combustion of which the nitrous oxide had not supplied sufficient oxygen. This quantity of hydrogen being too small to form a combustible mixture, it was necessary to make an addition of that gas, and to employ, for the second combustion, more oxygen than was requisite to saturate the hydrogen added. The quantity of hydrogen, originally in the mixture, was thus easily determined, and, when added to the volume of pure ni-

trous oxide expended, the sum expressed the whole hydrogen of the alkali.

In this more summary method of analysis, results were obtained, which fully confirmed those established by electrical agency, all concurring to prove that ammonia affords, by decomposition, a quantity of nitrogen and hydrogen gases equivalent to twice its volume, and consisting of 1 volume of nitrogen and 3 of hydrogen. To preserve, however, an agreement between the theory of volumes and that of atoms, it is necessary rather to view ammonia as constituted of 2 volumes of nitrogen and 6 of hydrogen. For since 2 volumes of hydrogen unite with 1 of oxygen to form water, every ultimate volume of hydrogen, (on the supposition that water is constituted of an atom of each of its elements) must, like the ultimate volume of nitrogen, be double that of oxygen. Two appreciable volumes of nitrogen, and two of hydrogen, will contain then the same number of ultimate particles or atoms, and multiples of 2 in volume of either gas, will be multiples of the numbers of single atoms of hydrogen or nitrogen. It must be acknowledged to be remarkable that the only known compound of nitrogen and hydrogen should, according to this view, be constituted of one atom of the former element and three of the latter; and that, during the decomposition of ammonia by electricity, those elements, disunited from each other, should not recombine in new proportions, as happens to the elements constituting the aëriform compounds of nitrogen and oxygen, when subjected to the same decomposing influence.

Article VII.

Reply to Mr. Daniell.

(To the Editors of the *Annals of Philosophy*.)

GENTLEMEN, *Oct.* 15, 1824.

Mr. Daniell having replied to my remarks on a part of his work, I hope you will give a place to what follows:

In Mr. D's first quotation he might have put the words "other circumstances being alike," in italics, the scope of my paper plainly showing that no effect of heat, except that of dilating the tube and its contents, was to be matter of discussion in as far as he was concerned. This restriction being now accurately understood, I proceed.

In the matter at issue between us, I must take the liberty of saying, that Mr. D.'s reply is totally incomprehensible and irrelevant. Mr. D. is the first who ever used the fraction of the apparent dilatation of mercury for correcting the observed height of the barometer; and since all writers, without excep-

tion, have taken the absolute quantity as the foundation of the requisite correction, it is needless here to name individuals who sanction the practice. There is really no imaginable case in which any other fraction can be applied, as it, and it alone, indicates that alteration in the specific gravity of the mercury, from which solely the necessity arises for the correction in question.

It would seem that Mr. D. confuses the nature of *thermometric* dilatation, with that which takes place in the *barometer*: perhaps he has not duly reflected that the fluid in the one instrument is isolated, and in quantity definite, whereas the barometric tube being an open vessel, allows the mercury to have free egress and ingress, whether these motions are caused by change of temperature or pressure of the atmosphere.

Were a column of mercury contained in a tube closed at the lower end, then indeed its expansion would be expressed by the fraction which Mr. D. contends is the proper one for barometric correction $\left(\frac{1}{64\cdot8}?\right)$, but this would be a *thermometer*, the action in which depends on vicissitudes of temperature alone; not like that in a barometer, which is modified, or rather mainly produced, by a cause altogether different.

A case, however, shall be taken which will, I presume, be deemed conclusive. Suppose three barometer tubes standing in a reservoir, and filled alike with mercury, but that one of the tubes *expands* by heating, that another *contracts*, and that the third neither expands nor contracts: no one will pretend to say, that if this apparatus be exposed to various temperatures, the columns in all will not rise to precisely the same height; here, therefore, as in every other case, the expansion or non-expansion of tubes may be utterly disregarded.

Moreover, as Mr. D. trusts to M. Biot in another matter, (of which below,) he may like to hear his opinion in this, by way of *argumentum ad hominem*; M. Biot says, tom. i. p. 86, "Dans cette recherche, *il est inutile* d'avoir egard à la contraction du tube du baromètre. Ce tube il est vrai, se resserre aussi par le refroidissement; mais sa largeur *n'influe pas* sur la hauteur de la colonne du mercure soulevée par l'atmosphere," and in accordance with this decisive explication, he constantly uses the fraction of absolute dilatation $\frac{1}{54\cdot12}$, for correction as to temperature of the column.

There is but one conceivable way in which the expansion of glass would require to be attended to: if the graduation, or inches for measuring the height of the column, were engraved on a plate of that material, then $\frac{1}{1162}\left(\sqrt[3]{1\frac{1}{387}} = 1\frac{1}{1162}\right)$ or lineal expansion, becomes the compensating quantity for 180

degrees of difference of temperature; whence is obtained for the number of degrees which the existing temperature is above or below 32°, the small fraction $\frac{d}{209{,}160}$; and not a fraction derived from that of the *cubic* dilatation of glass $\frac{1}{387}$, the number for which Mr. D. would insist, and which is in effect used also as one of the elements in the construction of Mr. Rice's table. For a scale on a plate of glass, the correction would be *affirmative* for degrees above 32°, and *negative* for those below that standard point, because in the former of these cases any line on the scale would be *in advance* of absolute or unexpanded distance, and vice versâ. This, however, is contrary to what Mr. D. says, if I have been able rightly to conjecture what he means by measuring upon a scale of glass.

As there is something portentous in the manner in which Mr. D. alludes to M. Biot, I shall, with due deference show where *his* error lies; to that gentleman truth will be acceptable from whatever quarter it may come.

In treating of absolute dilatation M. Biot says, "Elle est plus forte que la dilatation apparente, comme cela doit être," but precipitately he adds, "puisque celle-ci n'est réellement que l'excès de la dilatation propre du mercure sur celle du verre;" in one sense this may be true, but not in the way M. Biot understood it, he having made that a case of *addition*, which is one of *division*. In the preceding page (51) this apparent dilatation of mercury is stated to be $\frac{1}{63}$, and it appears from page 161, that $\frac{1}{380}$ is taken as the cubic dilatation of the vessel, $\left(\sqrt[3]{1\frac{1}{1142}} = 1\frac{1}{380}\right)$; of course, to find that of the mercury M. Biot makes $\frac{1}{63} + \frac{1}{380} = \frac{1}{54{\cdot}12}$. Now, not to mention an immaterial slip in this summation, the rule itself is fallacious, $\frac{1}{A} + \frac{1}{V}$ is not the absolute dilatation in question; $\frac{AV}{A+V+1} = M$* being the legitimate formula, which, as well as its two converse forms, holds universally true. In M. Biot's case therefore $\frac{1}{M}$ is $\frac{1}{53{\cdot}9}$ and not $\frac{1}{54{\cdot}12}$, the number used in the subsequent parts of his work. This oversight is not exclusively M. Biot's: Dulong and Petit, together with every writer on the subject, whose works I have perused, agree with the most ex-

* Whoever chooses to investigate this, will perceive that the symbols represent the volumes at 32°, as each of them plus unity does at 212°; or in other words, they are severally denominators of the fractions of the *apparent* dilatation of mercury, and of the absolute dilatations of the *vessel* and of *mercury*.

emplary uniformity in perpetuating the error. Mr. D. however, seems "perfectly assured that they are fully competent to defend themselves, if they think it worth while."

With regard to the depuration of mercury, Mr. D. mentions how I may extend my knowledge. I am myself a workman, although of name too obscure perhaps, ever to have reached Mr. D.'s ear; half a century, however, of experience in the habitudes of mercury, has enabled me duly to appreciate all available sources in information.

Surely Mr. D. does not imagine that any personal allusion was intended by the words mentioned in his concluding paragraph; they were used merely *in odium philosophorum*, and still must I be permitted to think the expression most appropriate. Even at this hour no one knows with certainty whether mercury expands $\frac{1}{50}$ or $\frac{1}{60}$, and in choosing a number each must be guided by vague predilection.

Hoping, however, that Mr. Daniell and I part good friends, I promise, in the event of his coming to take the altitudes of the Grampian range near which I reside, that he shall be shown how to detect the most minute impurity existing in mercury, by inspection of a single drop of that metal. X.

Article VIII.

On the Advantages, the Inconveniences, and the Comparative Danger of High, Mean, and Low Pressure Steam Engines. (Extracted from the Report to the French Institute, by MM. Laplace, Prony, Ampère, Girard, and Dupin.)

The subject resolves itself into the two following questions:

1. What are the relative advantages of mean and high pressure steam engines? and

2. What is the danger that attends them?

First Part.—*Comparative Advantages of High Pressure Engines.*

Amongst the advantages of high pressure engines, that of occupying the least possible space must be enumerated, and will be the more important, as the space for their erection is more confined, or the ground more valuable: where manufactories, and private houses, are so crowded together that each establishment can obtain but a very limited space, and great power is at the same time necessary, this advantage is particularly felt; and it is no less important in the interior of mines, for the same reason.

A second advantage of high pressure engines, and one that is even greater than the former, is the economy of fuel which results from the effects of a high temperature. This will be readily granted, when it is stated that the repairs and expenses of the steam-engines employed in draining a single large coal-mine in England, amount annually to the sum of 25,500*l.*

On this account several large proprietors of copper and tin mines, in Cornwall, adapted machinery to their engines, in 1811, by which an account is regularly kept of the work which they perform; and, from the results of these experiments, conducted on the largest scale, the comparative effect of the different kinds of engines has been ascertained for more than ten years.

In the month of August, 1818, the Cornish steam-engines raised 15,760,000 lbs. one foot high, for each bushel of coals consumed.

From December of the same year, the improvements were so material, either in the management of the engines, or in some of their parts, that the mean total product was increased to 17,075,000 lbs.

By a series of similar improvements, and by the construction of new and more perfect engines, the product was,

In December, 1812, 18,200,000 lbs.
——————— 1814, 19,784,000
——————— 1815, 20,766,000

and since 1815, the product is even still larger, in consequence of the improvements that have been made in the construction of the fire places, and boilers, and in short in every part of the machinery.

At the present day, it is calculated that Watt's improved steam-engines raise more than 30,000,000 lbs. of water one foot high, by the consumption of one bushel of coals.

By the side of this augmentation we must place that which results from the employment of Woolfe's steam-engines, which, as is well known, are condensing engines, and work with a pressure intermediate between that of the high and the low pressure engines.

Such a machine, with a double cylinder, has been constructed for the mine Whealvor, in Cornwall; the diameter of the large cylinder is 53 inches, and that of the small one 5·3 inches. This engine has raised 49,980,822 lbs. one foot high, by one bushel of coals, whilst the mean product of the other engines was only 20,479,350 lbs. raised to the same height.

In 1815 the mean product of two of Woolfe's engines was 46,255,250 lbs.

One of the inconveniences attending engines of mean and high pressure, is loss of power by the wear of the more delicate parts of their structure, and the consequent loss of steam; at

the same time it must be admitted that the improvements in the construction of the steam vessels have materially lessened this serious evil.

The preceding statements respecting the Cornish steam-engines, is taken from the reports published by Dr. Tilloch, in the Philosophical Magazine; and the more recent English Encyclopædias confirm the facts which have been stated.

Experiments made in France support the truth of these reports. MM. Girard and Prony have made separate comparative experiments on the power of low pressure engines, and the condensing engines of mean pressure on Woolfe's system, as improved by Edwards. They find that the latter deserves the preference, as to economy of fuel, though their results do not exactly agree as to the extent of the saving in this respect; their conclusions, however, tend to the same end, and their discrepancies are referable to particular circumstances.

Instead of estimating the power of a steam-engine by assuming the vague and ill-defined *power of a horse* as unity, it would be better to assume a given weight, raised to a given height in a given time; as 100 weight raised one yard in a second, which might be called *a power*. The working force of the engine would thus be indicated by the number of *powers* it is equal to, which may easily be ascertained by loading the piston with a sufficient determinate weight, and marking the space it passes through, so loaded, in one second of time.

The tension of the vapour being measured by its relation to the pressure of the atmosphere, taken as unity, it must always be referred to the standard barometrical pressure of 30 inches, and the temperature of 32°.

According to the preceding details, it may be assumed as incontestable, that it is most economical to employ steam at such a temperature, that its tension shall be equal to that of several atmospheres; but it is not so easy to decide to what exact tension it should be raised; or what is the mathematical law which expresses the product of steam-engines' powers in the function of the temperature, and the tension resulting from it.

"We have hitherto," says the report, "compared low pressure engines only with those of mean pressure; we now proceed to compare them with high pressure engines, which, as is well known, act without condensation of the vapour.

Mr. Trevithick, in England, and Mr. Oliver Evans, in America, are the persons who first made high pressure engines.

In 1814 Mr. Trevithick exported to Peru nine of these engines, for the purpose of clearing the mines of water, from the accumulation of which many of the richest had been abandoned: so effectual were the engines, that the treasurer of the province proposed to erect a silver statue to Mr. Trevithick, as

a memorial of the gratitude of the new world, for the services he had rendered it.

In Philadelphia, the saving in fuel by the substitution of one of Evans's high pressure engines for the low pressure one previously employed, amounted to about 1250*l.* per annum. This engine raises 20,000 tons (*tonneaux*) of water, about 98 feet in height, every 24 hours, and consumes about 1535 cubic feet of wood per diem. The prime cost of the machine was rather more than 5000*l.*; whereas, according to M. Marestier, a low pressure engine, of equal power, would cost considerably more than 8000*l.*

Evans's engines work with a pressure of from eight to ten atmospheres; several of them have been constructed in America; and in 1814 the Congress of the United States extended Mr. Evans's patent 10 years beyond the usual period, as an acknowledgment, on the part of the republic, of the benefit his invention has conferred on his country. A similar extension was granted in England, to Messrs. Boulton and Watt, for their condensing engines.

"More lately Mr. Perkins, an American, well known by his ingenious processes for employing steel plates instead of copper in engraving, has surpassed all his predecessors by the boldness of his conceptions. He employs, for his moving powers, steam under a pressure of more than 30 atmospheres, and apparently with great advantage.

"With respect to economy of fuel, we must, therefore, consider the high pressure engines, hitherto constructed, as not having attained the maximum. The use of condensed steam is yet in its infancy; and, notwithstanding the services it has already rendered us, we must consider them as far below what may still be expected, when we shall be more capable of availing ourselves of the full benefit of its effects."

Second Part.—*Measures of Safety.*

Habit reconciles us to danger. Hundreds of sailors perish annually by the power of the wind on the sails of our ships, and we think nothing of it, because we are become familiar to that mode of navigation. But if a *steam-boat* be blown up, or burnt, the accident is reported in the public prints to every corner of the world; the alarm is given, and that is looked upon as the most dangerous of all mechanical powers, which perhaps is the least so in the common course of navigation, and especially on nearing the land.

But destruction in some shapes is more appalling to the imagination than in others. Death from explosions, accompanied with noise and confusion, seems more horrible than when it comes in a more tranquil form; and in all our discussions on the relative dangers of different machines, we should divest

them of those accessary circumstances, which frequently produce the greatest effect on the minds of the vulgar and ill-informed.

Whenever man accumulates natural powers to effect certain purposes, they may, by mischance, be diverted from their proper courses, and become the cause of serious accidents; and no machine, by which those powers are concentrated, was ever constructed that has not its peculiar dangers.

To wish to employ only such machines as might be secure from the consequences of want of skill, imprudence, and rashness, were to wish to deprive ourselves of the happiest fruits of human skill and industry; at the same time it were a culpable neglect to suffer any man, for the sake of attaining an end of secondary importance, to employ means which might obviously endanger the lives and property of his neighbours. In such a case, public authority has a right to interfere, and exercise a beneficial and protecting influence.

Does this observation apply to steam-engines in general, or only to a particular class? Should the use of high and mean pressure engines be restricted to certain situations?

The British Parliament has lately taken this subject into serious consideration, and has adopted most of the precautions recommended by a Committee of the House of Commons, appointed to inquire minutely into it, particularly with the view of obviating the dangers to which steam passage-boats are liable from ill-constructed machinery, carelessness, or mismanagement. The Committee particularly recommended, that the boilers of the steam-engines shall be made of wrought iron or copper, and furnished with safety valves, of proper size and form, one of which shall be so secured as to be inaccessible to the workman who has charge of the engine: it also recommends that this valve shall be loaded only with such a weight that the pressure shall never exceed one-third of that, which the boiler has been found, by actual trial, to be capable of supporting without bursting, or one-sixth of its calculated strength; and that any person overloading the valve shall be liable to punishment.

Although the British Legislature has not forbidden the use of high pressure steam-engines, either in passage-boats or manufactories, the preference has been given, especially for boats, to low pressure engines; and much prejudice has been excited against the former from deplorable accidents which have occurred in America, in England, and France. Mr. Evans, however, according to Mr. Marestier, has defied his opponents to produce a single instance of the explosion of one of his engines, although they work with a pressure of 10 atmospheres.

But serious accidents are not confined to high pressure engines—they have happened with those of low pressure, both

in England and America; and more than once, explosions occasioned by the latter have been attributed to the former.

An account is given by Mr. Stevenson, in the Edinburgh Philosophical Journal,* of a dreadful explosion which occurred near Edinburgh, of a high pressure steam boiler; and in France accidents have happened both with low, mean, and high pressure engines, which require our particular attention.

Explosions, which have cost many persons their lives, have happened with what are *called low pressure* engines, but which in reality cease to be such whenever the fire is strongly urged, and the escape of the condensed steam prevented, either by the accidental derangement of the safety valves, or by its being purposely overloaded. Amongst others, we may mention the deplorable accident which happened at Creusot, by which many individuals were killed, by the bursting of the boiler of a *low pressure* engine. Let us turn to the other engines. At Péronne the balance beam of an English high pressure engine having broken, the steam in the cylinder drove up the piston and its rod through the planks and roof of the building in which it was placed; but no person was killed or hurt.

At Paris the lower part of the boiler of a mean pressure engine having split, the water flowed into the fire-place, and put out the fire; the walls of the furnace were not even shaken, and no noise was heard except that of the rupture of the boiler. A similar accident occurred about three years since in another establishment, unattended by any more serious consequences.

But at Essonne a more serious accident happened lately with a mean pressure engine, the boiler of which had been cast at a foundry not calculated for such work; and it has been satisfactorily proved, that the mischief was occasioned solely by the clumsy construction of the boiler, and the faulty manner in which its parts were put together.

It results, from all the details which we have collected, that no mean or high pressure steam boiler, constructed in any regular establishment in France, has ever met with an explosion; although they are more numerous than those imported from foreign countries. During the last year 36 of these engines have been made in one manufactory at Paris, and a still greater number are making in the present year; and the more they are used the more they are approved of. Since 1815 more than 120 mean and high pressure engines have been made in the French manufactories.

Since 1815, 32 mean pressure engines have been sent to St. Quentin, from one manufactory at Paris; and the purchasers are universally well satisfied with the service they perform.

* Vol. v. p. 147. This boiler was erected for boiling the stills of the Lochrin Distillery, by high pressure steam.—C.

It became important to ascertain if the safety of the French engines, from their introduction to the present time, be merely owing to chance, or if it be the necessary consequence of multiplied precautions in their manufacture, and the previous trials to which the boilers are submitted. On this point the following information has been obtained respecting the cast iron boilers, which are considered as the most unsafe.

The mean-pressure, condensing engines, on Woolf's construction, are those which are made in the principal manufactory in France. With these engines the pressure may be varied from that of one atmosphere to two and a half, or three atmospheres, and is indicated by a mercurial gauge.

The true boiler and boiling pipes in Woolf's engines (which must not be confounded) are made of the purest cast iron. The form of the boiler is cylindrical, its axis being horizontal.

The thickness of the boilers and boiling pipes of large and small steam-engines, varies from about an inch and a quarter to an inch and three quarters. The diameter of the boiling pipes is much less than that of the boiler; for small engines it is less than half, for large engines less than one-third of the diameter of the boiler.

The axes of the boiling pipes are parallel to the axis of the boiler; they are placed below it, and immediately over the fire-place, in such a way that the flame is in contact with the pipes only.

As the boiler is less exposed to the fire than the pipes, it is less subject to injury from its action; and if any part give way from that cause, it is the lower part of the pipes and not the boiler; the consequence of which is the inundation of the fire-place, and extinction of the fire, as happened in one of the accidents mentioned above.

The parts of the engine are united with every possible attention to strength, and to closeness at the joints, so that there may be no loss of power from the escape of steam.

Before the pipes and boiler are used, they are separately submitted, by a hydraulic press, to five times the pressure that they will have to support when the engine is at work.

Before any conclusions are drawn from the preceding facts and observations, it may be well briefly to recapitulate them.

High-pressure steam-engines are employed with most advantage.

1st. Because the greater the compression of the steam, the less is the space the engine occupies.

2d. Because it produces an equal power to that of a low-pressure engine, with a smaller quantity of fuel.

But they are considered as more dangerous than low-pressure engines. Nevertheless engines may be constructed, with which

explosions, if not absolutely impossible, are at least extremely rare; and with which not a single instance of an explosion has occurred in France, since they have been used in that country.

Such are the mean-pressure engines, of three or four atmospheres, made in France, on Woolfe's construction, as improved by Edwards, with boilers four or five times stronger than can be burst by the force of the steam which they have to resist.

Such also are the high-pressure engines of 10 atmospheres, constructed on the plan of Oliver Evans, of the United States of America. With these engines the boiler is capable of resisting ten times the force it is daily subjected to.

But engines constructed with less care, or managed with less prudence, have occasioned dreadful accidents, especially in Great Britain.

In France only one accident has ever happened, by which any lives were lost, which were those of two individuals engaged in the service of the engine; and not one single instance has occurred in that country, in which any damage has been sustained by any individuals, from the explosion of a steam-engine on the adjoining premises.

Although it appears, from the preceding statement, that no one in the neighbourhood of a steam-engine, in France, has ever suffered either in his person or property from any explosion, yet the impossibility of such consequences has not been proved; and the bare apprehension of the danger is a real evil, attendant on the erection of a mean or high-pressure steam-engine in the neighbourhood of a dwelling-house. To reduce that apprehension as much as possible the following precautions should be adopted.

1. Every steam-engine boiler should be furnished with two safety valves, one of them inaccessable to the workman who attends the engine, the other under his command, in order that he may be able to diminish the pressure on it, as occasion may require. If he attempt to overload this valve, it will have no effect, since the steam will find vent through the other, which is out of his reach.

The reporter, M. Dupin, suggests in this place, that if any apprehension of danger be entertained, from the possibility of the inaccessable valve becoming fixed by rust, or negligence, it may be obviated, by fixing in the upper part of the boiler two plugs of fusible metal, formed of such an alloy, as to melt at a few degrees above the working temperature of the steam. One of these plugs is to be considerably larger than the other, and to be made of a rather less fusible alloy, so that if the steam does not escape with sufficient rapidity on the fusion of the smaller, it may have ample room to fly off, as soon as the larger has given way. The temperature, at which the least

fusible alloy melts, must of course be considerably below that at which the increased elasticity of the steam would endanger the safety of the boiler.

2. All the boilers should be proved by being submitted, by means of the hydraulic press, to four or five times the working pressure, for engines that work with a pressure of from two to four atmospheres. Beyond that term the proof pressure should as much exceed the working pressure, as the latter exceeds the simple pressure of the atmosphere.

3. Every steam-engine maker should be obliged to make known his method of proving the boilers, as well as whatever may guarantee the solidity and safety of his engines, especially as regards the boiler and its appendages. He should also declare this working pressure, estimated by the number of atmospheres, or in pounds, on each square inch of surface exposed to the action of the steam.

4. For further security, the boilers of very powerful engines, when near a dwelling-house, may be surrounded by a thick wall, at the distance of between three and four feet from the boiler, and at least as far from the party wall of the adjoining house.

Lastly, if an exact account were taken, and published by the proper authorities, of all accidents that happen to steam-engines of every kind, minutely detailing both the causes and effects of such accidents, with the names of the proprietors, and the makers of the engines, it would mainly tend to render unfrequent, though it cannot wholly obviate the evils that may arise from the use of mean and high-pressure engines.

Article IX.

An Account of the Columbite of Haddam (Connecticut). By John Torry, MD.*

The history of columbium is recorded in almost every work on chemistry and mineralogy, and is familiar to all who have made those sciences their study. Though it is now twenty years since Mr. Hatchett made his interesting discovery, the only North American specimen of columbite known until lately, was the original one in the British Museum, and even the precise locality of that is not known. It is said to have been sent many years since by the late Governor Winthrop, of Connecticut, to Sir Hans Sloane, then President of the Royal Society; after whose death it was deposited in the Museum, where it still remains. According to a notice in the eighth volume of the New York Medical Repository, the locality is said to be near a

* Annals of the Lyceum of Natural History, New York.

spring not far from the house of Gov. Winthrop, near New London. It has, however, been many years sought for without success; and some mineralogists have doubted whether the specimen in the British Museum was found in Connecticut, or in any part of this country; but that it was a Swedish specimen of tantalite, which had by mistake been labelled as North American.

In a collection of minerals which I sent many years since to Count Trolle Wachtmeister, this distinguished savant informed me, that in one of the specimens from Haddam, containing cymophane, beryl, &c. Prof. Berzelius had detected the tantalite, and that it exactly resembled that of finbo, in Sweden. A notice of this discovery I published in the fourth volume of Silliman's Journal, but it has been overlooked by Cleaveland in the second edition of his excellent work, and also by Phillips, in the last edition of his Mineralogy. As soon as I received this interesting information, I carefully examined the one or two specimens of the Haddam rock remaining in my possession; but without finding the substance which I supposed Berzelius alluded to; and since that time until lately, I had made no other search for it. A few weeks since, however, in examining some splendid specimens of the above-mentioned remarkable rock, presented to me by Col. Gibbs, I observed, disseminated through one of them, several small masses of a blackish substance, having the appearance of an ore of manganese. On a more attentive examination, it presented some unusual characters, and at length I discovered a considerable number of minute crystals, which were evidently of the same mineral with the masses. It occurred to me that this was the tantalite of Berzelius, and a chemical examination of the small portion of the mineral which I could sacrifice for this purpose, left little doubt on the subject. The following is a more particular description of the mineral.

It occurs in small amorphous masses, and in minute crystals, disseminated in a granitic aggregate, consisting of quartz, albite,* talc, friable manganesian garnet, beryl, cymophane, &c. The amorphous masses, which are probably very imperfect crystals, are from one-fourth to half an inch in diameter, of a greyish black colour, with the surface always more or less irised. It is opaque. Its structure is imperfectly foliated. Its fracture is somewhat conchoidal. It is not magnetic, either before or after being heated by charcoal. It is sufficiently hard to scratch glass, but not to strike fire with steel. The powder of the mineral is very dark brown. Specific gravity 5·90. Before the blowpipe, it is nearly infusible, the smallest fragment being

* Cleavelandite of H. J. Brooke, Esq. as proposed in the last edition of Phillips's Mineralogy. It is a subject of regret that this name must be given up for that of albite, the latter having been several years since proposed by Hisinger and Berzelius for those varieties of feldspar having a base of soda.

slightly rounded on the edges. Borax dissolves it very slowly, forming a pale yellowish glass. The crystals are very minute, being seldom greater in diameter than a common pin, and often much less; yet many are extremely perfect. The greater number of these crystals is imbedded in the singular friable garnet, which Mr. Seybert has ascertained to contain 30 per cent. of manganese. In one instance, I found them long, very slender, and disposed in a radiating manner. They are often grouped, or intersecting, and are very brittle. The form of the crystal is that of a compressed rectangular prism, usually truncated on the lateral edges, or a four-sided pyramid, two sides of which are, in most instances, unduly extended. According to Phillips, the primary form of the columbite is a right rectangular prism. The annexed figures represent two of the crystals with the measurement of the angles taken with the reflecting goniometer. No. 1 is the most common. This, it will be seen, much resembles a figure of columbite in the third edition of Phillips's Mineralogy, except in some minor truncations.

Fig. 1.

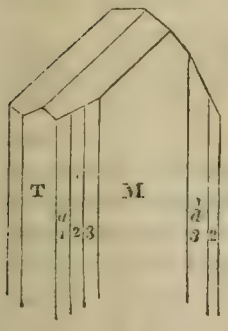
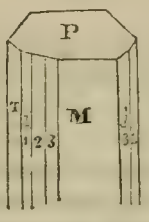


Fig. 2.



P on M, or T	90	00
M on T	90	00
T on *d*1 or M on *d*3..	157	00
T on *d*2 or M on *d*2..	129	50
T on *d*3.	102	50

A small quantity of the powdered mineral was fused with six parts of potash and one of borax. A mass of a deep green colour was obtained. Muriatic acid poured on this left a white powder, which, from the small quantity of the ore operated upon, could not be particularly examined, but it appeared to be oxide of columbium. The muriatic solution was found to contain iron and manganese. I regret exceedingly not having a sufficient quantity of the mineral to make a complete analysis, but its external characters, crystalline form, and the few chemical experiments I have made, together with the great probability of the substance I examined being the same alluded to by Berzelius, leave little doubt that it is columbite. Still, I hope, by examining a considerable number of specimens, to find a sufficient quantity of the ore to undertake a detailed analysis.

If I am correct in my determination of the Haddam mineral, we have a clue, perhaps, to the discovery of the long-lost colum-

bite. The original specimen is said to have been found in New London, which place is not more than 25 miles from Haddam. It is true that the largest piece of ore yet seen from the latter locality, does not much exceed half an inch in diameter, while that in the British Museum is said to weigh several ounces;* but it is reasonable to expect, that when the new locality is thoroughly explored, masses of considerable size will be discovered. There is another circumstance which favours the opinion that the mineral analyzed by Mr. Hatchett is of the same variety, and from the same locality, as that of Haddam, which is, the specific gravity of the latter. The North American columbite was found by Dr. Wollaston to be much lighter than that of Sweden; the cause of which was supposed to be small cavities in the former; and in confirmation of this opinion, I would mention that the Haddam columbite, when immersed in water, continued to give out minute bubbles of air for a considerable time, after which the specific gravity was much increased.

Article X.

On the Misstatements in the Morning Chronicle and Times Newspapers respecting Sir Humphry Davy's Method of protecting the Copper Sheathing of Ships' Bottoms.

In my answer to an attack on the originality of Sir Humphry Davy's plan for defending the copper sheathing of ships,† I have said that the defended metal is more liable to become foul from the adhesion of weeds, barnacles, &c. than the undefended. Such a statement first appeared in a provincial paper about June or July last, and was copied into some of the London daily prints, but I cannot now recollect the names of either the one or the other, a circumstance, however, of no consequence to my present purpose. The fact was stated in positive terms, and I was informed by what I believed to be good authority, that it was correct. I was the less anxious to inquire more particularly into it, because, even if true to the full extent, I felt convinced that Sir Humphry Davy would find no difficulty in obviating the evil, by reducing the energy of the defensive action; and my conviction on that head remains unshaken. Had my inquiries, however, been more minute, I should have been more guarded in admitting the fact as a general result; for I have since learned that the assertion requires much qualification to make it consistent with truth.

I do not know whether or not the passage in question has

* It weighs exactly 302·46 grains.—C.

† *Annals of Philosophy*, vol. viii. (New Series) p. 141.

given rise to several erroneous statements which have lately appeared in some of the London papers; but the subject having been revived, and as it appears to me in no very laudable spirit, I am anxious at least to do away any false impressions that I may have unintentionally occasioned, by putting our readers in possession of such facts as have recently come to my knowledge, and on the accuracy of which they may rely.

But, first, a word or two as to the newspaper assertions. In the Morning Chronicle of Oct. 10, an extract is given from a weekly publication, called "The Chemist," which, after denying to Sir Humphry the merit of originality, concludes; "There is, however, a more serious objection to the method proposed. *It has been tried, and it has failed.*" This is a short way of settling the question at all events, and when we are indifferent whether the decision be just or not, is, perhaps, as good as any other. Pretty much to the same purpose, and perfectly in the same spirit, is an article in the Times newspaper, Oct. 16, on the same subject. After stating Mr. Muschett's experiments, it speaks thus of Sir Humphry's:—"The experiment so far succeeded as to protect the copper from decay, but it was soon found out that vessels covered on this plan have returned after short voyages perfectly foul; their bottoms covered with sea weeds, barnacles, and other worms. The remedy, therefore, is worse than the disease." A little further, we have another *therefore*. "The learned President's experiments may, therefore, be regarded as a failure, so far as advantage to navigation is concerned, however useful they may be to chemical science, and however pleasant they may have been to himself in procuring a summer excursion at the public expense to the North Sea and the Baltic."

Whether these and similar attempts to prejudice the public mind against an invention which there is every reason to believe will afford an effectual remedy for a serious national evil, are to be attributed to sheer ignorance, or a less venial origin, I know not; but whatever bears the impress of superior intelligence, is sure to provoke the spleen of invidious sciolism. It was so with another important discovery of Sir Humphry Davy's, for even the precious boon of safety to thousands could not protect his Lamp from the sneers of certain petty cavillers. Posterity will be more just!

But to the *facts*, and by their evidence let our readers judge of the *accuracy* and *justice* of the newspaper statements, and the bold assertion, that the experiments have failed.

The two harbour boats which gave rise to the original exaggerated account, were *purposely over defended* by a surface of zinc in the proportion of about 1-25th of that of the copper, the object of those preliminary experiments being solely to ascertain the *efficacy of the plan as a preservative of the copper*, without

reference to any ulterior effects. These boats were stationed in Portsmouth Harbour, and the copper remained bright for nearly three months, when it became coated with carbonate of lime, to the rough surface of which, the confervæ, always floating in the summer months in Portsmouth Harbour, adhered, and these soon caught other weeds; but they were all *loose*, and there were neither *barnacles, nor any other shell-fish, nor any worms*, amongst them; and it is more than probable, that the same weeds would have adhered even to carbonate of copper.

Except in harbour, there is every reason to think that carbonate of lime could not adhere to the copper, even *with excess of protection*, and the confervæ must have been washed off in a ship at sea. Copper, until it is worn in *holes*, corrodes so fast that no permanent surface remains to which weeds can adhere; but when there are inequalities in the surface, they adhere readily enough even to the poisonous oxide of copper. I do not believe that any of the protectors placed upon *ships* are in such excess as to occasion any deposit, and if they are a little positive, or nearly in equilibrio, the whole surface remains smooth, and the adhesion of weed and shell-fish is prevented. As far as the experiments hitherto made enable one to judge, the requisite proportion of protecting surface to that of the copper is somewhere between $\frac{1}{120}$ and $\frac{1}{220}$, but even $\frac{1}{300}$ will save more than half the copper of the navy.

In reply to the assertion that protected ships have returned after short voyages *perfectly* foul, and the delicate insinuation that Sir Humphry Davy has been amusing himself by a voyage to the Baltic at the public expense, I subjoin the following note to the Secretary to the Admiralty, and his answer.

MY DEAR SIR, *British Museum, Oct.* 22, 1824.

You have seen, no doubt, a paragraph in the Times newspaper of the 16th instant, stating "that vessels coppered on Sir Humphry Davy's plan with protectors *have returned after short voyages perfectly foul.*" In the same paragraph, it is also insinuated, that *Sir H. D.'s late voyage to the Baltic was made at the public expense.* Pray allow me to ask you if these statements, or either of them, be correct or otherwise?

I am, my dear Sir, your faithful servant,

J. G. CHILDREN.

John Barrow, Esq. &c. &c. &c. Admiralty.

MY DEAR SIR, *Admiralty, Oct.* 22, 1824.

In answer to your inquiries respecting vessels coppered on Sir Humphry Davy's plan with protectors having returned after short voyages perfectly foul; and whether Sir Humphry Davy

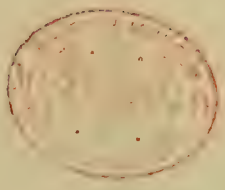
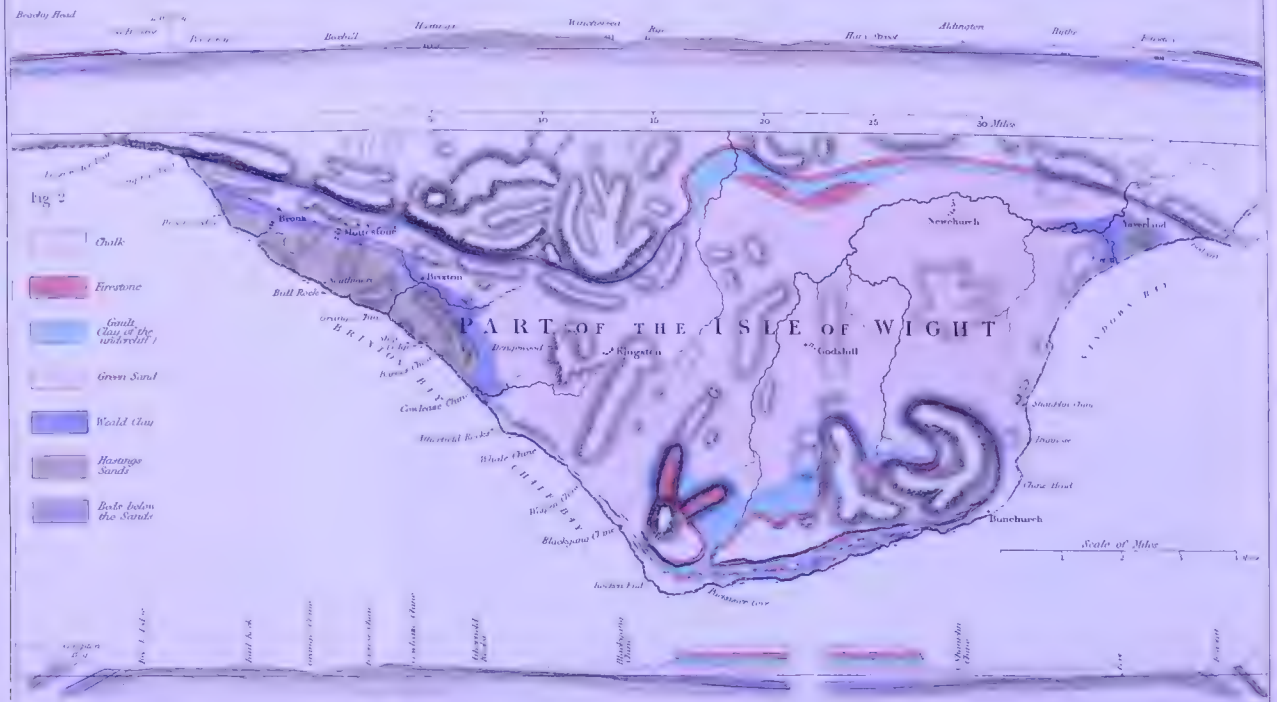


Fig. 1



Engraved for the Annals of Philosophy for January 1820 by Jas. Nay

made a voyage to the Baltic at the public expense, I have to state, that with regard to the former, *no report whatever has been received at this office from any one vessel supplied with protectors, nor am I aware that any one of them has returned into port.* And with regard to the second point, I can safely say, that Sir Humphry's passage to the Raze of Norway (not to the Baltic), *was not attended with any expense either to this or any other department of government.* The fact is simply this:—the Comet steam vessel having been ordered to proceed to Heligoland at the express request of the King of Denmark, for the purpose of fixing with precision, by means of numerous chronometers, the longitude of that island, in order to connect the Danish with the British survey; and the Board of Longitude having recommended that the voyage should be extended as far as the Raze of Norway, for the purpose of ascertaining the longitude of that important point, Sir Humphry Davy volunteered to proceed in her, *at his own expense*, to enable him to attend in person to certain experiments which he was desirous of making on the action of sea water on the copper of a vessel passing rapidly through that medium.

If any illiberal construction should have been conveyed to the public, as your note would seem to imply, you are at liberty to make use of this reply in any way you may deem fit.

I am, my dear Sir, very sincerely yours,

JOHN BARROW.

J. G. Children, Esq.

Verbum non ampliùs addam.

J. G. C.

ARTICLE XI.

Inquiries respecting the Geological Relations of the Beds between the Chalk and the Purbeck Limestone in the South-east of England. By William Henry Fitton, MD. FRS. MGS. &c. (With a Plate.)

I. THE geological relations of the beds of sand and clay which are interposed between the chalk and the Purbeck limestone have been of late the subject of considerable discussion; and various opinions have been formed respecting the difference of structure supposed to exist in the two principal tracts, where this part of the British series of strata is visible upon the coast, namely the southern shore of the Isle of Wight, and the space between the chalk cliffs near Folkestone and at Beachy Head. Nothing can more strongly show the necessity of further information upon this subject, than the discrepancy in the accounts of these two districts, and the general obscurity of all

that relates to the beds between the chalk and the Purbeck limestone, in the "Outlines" of Messrs. Conybeare and Phillips; a work so very remarkable for the judgment and success with which its multifarious contents have been brought together and rendered consistent. In the account of the wealds of Kent and Sussex,* described for the first time by Mr. Conybeare in that publication, the tract between the chalk and the Hastings sands is said to be occupied by a ridge composed of 'Green sand,' quite distinct from the 'Iron sands' of Hastings, and separated from them by a well-marked valley, containing the 'Weald' clay. But in the description of the Isle of Wight,† the very same denominations are applied to strata entirely different; the author adopting the arrangement of Mr. Webster, and regarding the lower part of that island as composed of one series only of ferruginous sands, which he identifies with those of Hastings: so that the reader of the descriptions afterwards given of other parts of England, in which these sands and clays occur, must connect with those terms a different meaning, according to the district which he may happen to have first seen, or may adopt as the type of his comparison. Mr. Conybeare indeed has himself admitted the obscurity in which this part of the British series of strata is involved; and has ascribed it, not merely to the imperfect state of our information, which seems to me to be the true cause, but to a greater variation of structure and composition in these beds, when occurring in different quarters, than has been observed in other members of the series,—or than will, I believe, be found in reality to exist.

The standard publication to which Mr. Conybeare and all other geologists have referred, in treating of the Isle of Wight, is the well known letters of Mr. Webster to Sir Henry Englefield,‡—a work which has given to that instructive district an almost classical celebrity, and has contributed most essentially to the recent progress of geology in this country. It seems to me, however, from what I have recently seen, that Mr. Webster's arrangement of the lower strata of the Isle of Wight has been adopted without sufficient examination; for though he has identified in a general manner the sands of Hastings and Tunbridge Wells with his ferruginous sands, and stated that the weald clay belongs to this formation, and has also mentioned grit stone as occurring in it, he does not appear to me to have duly appreciated the relations of the different members of this part of the series; having overlooked the important natural features resulting from the presence and situation of the weald clay, and mentioned the Purbeck beds as constituting the lowest strata of the Island. From a paper recently presented to the Geological Society by Mr. Webster, an abstract of which has been pub-

* Outlines of the Geology of England and Wales, p. 144, &c.
† Page 135. ‡ London. 4to. 1816.

lished in *The Annals of Philosophy*,* it would also appear that he is of the same opinion with Mr. Conybeare as to the want of continuity and correspondence of those formations in different quarters; for he states that the siliceous limestone of Hastings had not been noticed in any other place, and describes it as not being coextensive with the rest of the ferruginous sand.

It is unnecessary to enter further into the history of this subject, as the subjoined list enumerates the principal authors who have published any thing relating to it, and will show the connexion of their several arrangements. But I should hardly have ventured to differ from such authorities, if the structure of those tracts in Kent and Sussex which are composed of the beds under consideration were not obscure; and if, also, it did not appear from Mr. Webster's own account, that the portion of the Isle of Wight to which my observations relate, had comparatively escaped his notice;† since it is not possible to examine the country which he has more particularly described, without admiring the fidelity of his observations, and admitting the general soundness of the inferences he has deduced from them.

II. The fact is, that there exist, in the Isle of Wight, as in the wealds of Kent and Sussex,—besides the beds of greenish sandstone immediately beneath the chalk,—*two* distinct series of sands which differ from each other considerably in composition; and that the features of the surface also correspond with the geological division of the strata, although local circumstances have rendered this connexion less conspicuous in the Isle of Wight than in the wealds of Kent and Sussex. *Both* of these sands are separated from the beds above them to which Mr. Webster has confined the denomination of green sand, by a stratum of blue clay; and the two sands themselves are again distinctly separated by a second stratum of clay, precisely corresponding, both in situation, and in the fossils which it contains, with the weald clay of Kent and Sussex. It is the inferior of these sands alone which is the equivalent of the Hastings beds; and these constitute the lowest formation visible in the Isle of Wight: the true Purbeck beds not appearing at all upon the coast, nor, I have reason to believe, any where in the interior of the island.

* July, 1824, see p. 67 of the present volume.

† See Letter, pp. 148, 154. &c. The sources of misconception upon this subject have not improbably been, the confused state of the lower beds at Sandown Bay, where Mr. Webster began his observations in the Isle of Wight, and the strong resemblance of some of the beds which there occur in the weald clay to the Purbeck limestone; by these circumstances, Mr. Webster, and, perhaps, subsequent observers, have been misled as to the true relations of the lowest strata of the island, and prevented from examining other parts of the coast where they are better displayed.

The annexed map and section (Plate XXXIII, fig. 2,*) will show the relative situation of the strata, and will explain the circumstances which render the exterior of the low country, at the back of the Isle of Wight, somewhat different in appearance from that of Kent and Sussex, which it really does resemble. The ridge of vertical chalk strata which traverses the whole of the Island from east to west, is succeeded on the south by a parallel range of low hills, consisting of sand, and separated from the chalk by a narrow valley occupied by blue clay: this lower range resembles both in composition and relative place, that which occurs between the chalk hills and the Hastings sands, throughout the greater part of Kent and Surry; and near the coast of the island, it is succeeded by a still lower tract, denoting the situation of the weald clay—from beneath which, as in Sussex, the Hastings-sands rise distinctly near Brook Ledge, and also, but less obviously, in Sandown Bay. If, where the chalk recurs in the south of the island, its inclination had been similar to that of the central beds, we should probably have had between the two chalk ranges a parallel ridge of iron sand, with a succession on both sides of similar beds in the same order; and the section of the coast at the back of the Isle of Wight, both on the south-west, from Compton Bay to Rocken End, and on the south-east from Chine Head to Culver, would have corresponded exactly to that of the shore between the cliffs of Dover and Beachy Head. (Fig. 1.) But the southern platform of chalk being nearly horizontal,—its distance from the central ridge inconsiderable, and the outcrop of the two ranges not parallel but converging towards the interior, the beds of sand which come from beneath it, meet the corresponding strata which rise from under the central chalk, so as to conceal the lower beds of the series. It is, therefore, only where the streams have cut deeply through the surface, or on the coast, where the upper strata have thinned out, that the Hastings sands can make their appearance; and when they do occur upon the shore, their section exhibits lines of unequal curvature, with the greater inclination, on both sides, next to the central ridge of chalk.

In looking westward from the heights above Rocken-End, the structure now described is plainly discernible:—the Green sand thins off gradually to Atherfield Point, but forms in the interior a continuous range of low hills from Walpen Chine to Kingston, on the west of which place are some eminences of sand; and from thence the range of sand hills already mentioned can be traced without interruption to the shore at Compton Bay. The low country of the weald clay is also seen

* This map is reduced from the ordnance survey, coloured after Mr. Webster, with the necessary alterations on the coast; the general relations of the strata being the object, accuracy of local detail has not been attempted.

HALK TO THE HA

s of different Geologists.

Names according t		
	Buckland. (Synoptic Table.)	Sedgwick. (*Annals*, May, 1822.)
	"Chalk."	"Chalk."
	"Chalk marl."	
	"Grey chalk."	"Golt."
	Isle of Wight; "Green sand."	In the Isle of Wight, "Green sand."
	In other places a variety of the grey chalk;—or taken for the Green sand, No. 4.	In Cambridgeshire, "Indurated chalk marl."
	In the Isle of Wight, taken for Tetsworth clay, No. 5.	"Golt," Cambridgeshire.
	In other places, regarded as a variety of the chalk marl.	In the Isle of Wight, considered as the Tetsworth clay, No. 5.
	"Green sand."	In the Isle of Wight, not distinguished from No. 6.
	In the Isle of Wight; not distinguished from the Iron sand, No. 6.	Fossils described as belonging to the Iron sand.
	"Tetsworth clay."	"Iron sand."
	In the Isle of Wight, the clay of the Undercliff No. 3, is taken for this bed.	Fossils described as belonging to the Iron sand.
	"Iron sand."	Iron sand supposed to possess the fossils of No. 4.

LIST OF STRATA FROM THE CHALK TO THE HASTINGS SANDS.

With the Synonymes of different Geologists.

... as they exist in the Isle of Wight	*Other places of their occurrence.*	*Names according to different Geologists.* — Webster. (Letters to Sir H. Englefield.)	Smith. (Maps, sections, &c.)	Greenough. (Geological map.)	Buckland. (Synoptic Table.)	Mantell. (Geology of Sussex.)	Conybeare and Phillips. (Outlines of the Geology of England, &c.) — In the Isle of Wight.	Conybeare and Phillips. — In other places.	Sedgwick. (*Annals*, May, 1822.)
CHALK, with flints.	Passin.	"Chalk."	"Chalk."	"Chalk."	"Chalk."	"Chalk."	"Chalk."	"Chalk."	"Chalk."
without flints.					"Chalk marl."	"Grey chalk marl."			
grey (marly).	Eastern foot of Beachy Head. Swanage Bay; foot of Ballard-hill.	"Chalk marl."			"Grey chalk."				"Galt."
blush.									
Greenish sand and sandstone; with concretions of chert, and ...stone. Firestone.	Cambridgeshire. Lower part of the "Clunch," (*Hailstone*, Geol. Trans. iii. p. 45.)	"Greensand." "Firestone of Reigate, &c." (Geol. Trans. v. p. 353.)	"Green sand, at the edge of the chalk hills." (Table.—Maps of Sussex and Wilts.) "Sand and firestone." (Section London to Brighton.) "Lower chalk, firestone, &c. (Berks.)	One colour. "Blue marl and green sand."	Isle of Wight; "Green sand." In other places a variety of the grey chalk;—or taken for the Green sand, No. 4.	In general not distinguished from the lower part of No. 4. Probably the "Malm rock" of Western Sussex. (p. 84.)	Exclusively, "Green sand."	Part of the "Chalk marl." Sometimes appears to be taken for No. 4.	In the Isle of Wight, "Green sand." In Cambridgeshire, "Indurated chalk marl."
...ay of the undercliff; blush, ...sh to the touch; in the Isle of ...ight, with few fossils	Cambridgeshire. *Gault.* Shiere, near Guildford. Nutfield, Surrey Folkestone. Beneath Sea-houses, Sussex. Swanage Bay. Worbarrow Bay.	"Blue marl."	"Indurated, micaceous brick earth, (Strata identified, p. 13.) "Galt brick earth." (Map of Sussex, Wilts, Section, &c.)		In the Isle of Wight, taken for Tetsworth clay, No. 5. In other places, regarded as a variety of the chalk marl.	"Blue chalk marl." "Galt."	Considered as the "Weald clay," No. 5. (Outlines, p. 158.)	Part of the "Chalk marl."	"Galt," Cambridgeshire. In the Isle of Wight, considered as the Tetsworth clay, No. 5.
...ds, ferruginous and reddish ...ur; green, with numerous ma... fossils, in the lower part.	Range of hills intermediate between the chalk and the wealds of Kent and Sussex.	This bed, almost exclusively, described under the name of the "ferruginous sands."	"Sand and sandstone." (Maps of Sussex and Surrey, &c.) "Sand beneath, the Galt brick earth," Wilts. The position correct; but the lower part erroneously stated to contain the *Portland rock*.		"Green sand." In the Isle of Wight; not distinguished from the Iron sand, No. 6.	"Green sand."	Part of the "Iron sand."	"Green sand."	In the Isle of Wight, not distinguished from No. 6. Fossils described as belonging to the Iron sand.
...ay of the Wealds. Slaty clay and ...estone; with various fossils, principally of freshwater (Cypris, Paludina, Cyrenæ, oysters, bones of ...es, &c). Beds of shelly limestone, ...d of ironstone. Pyritized wood, ...of lignite	Hythe. Bethersden, Kent. Petworth, Sussex. Punfield, north of Swanage Bay	The clays regarded as subordinate to the ferruginous sands. The limestone as probably belonging to the Purbeck series.	"Oaktree clay," considered as the same with the Kimmeridge clay.	"Tetsworth clay."	"Tetsworth clay." In the Isle of Wight, the clay of the Undercliff No. 3, is taken for this bed.	"Oaktree clay."	"Iron sand." Probably regarded as subordinate to the sands.	"Weald clay."	"Iron sand." Fossils described as belonging to the Iron sand.
...nds and sand rock; frequently ...uginous; with numerous alter... ...ions of reddish and variegated ...dy clays, and concretions of ...rous grit. Wood. Iron... ...e. *Freshwater* shells. Bones ...bles, and of Saurian animals.	Hastings. Winchelsea Rye, Sussex. Swanage Bay, south of Punfield.	Partially included, with Nos. 4 and 5, under the name of ferruginous sands. The beds not supposed to be continuous or identical in different situations.	"Sand and sandstone beneath the oak tree clay." This bed, in some of Mr. Smith's county maps, appears to be confounded with No. 4?	"Iron sand."	"Iron sand."	"Iron sand."	Part of the "Iron sand."	Exclusively, "Iron sand."	Iron sand supposed to possess the fossils of No. 4.

"Ferruginous sands."

to form a continuous valley, from the west of Atherfield rocks through Brixton, and thence to Brook; and from this depression the ground rises gradually on all sides to the coast, so as to resemble a portion of a flattened dome. A similar structure, and the same succession of beds, may be seen on the other side of the island, from the heights above Bonchurch, eastward to Culver; but the sands there occupy a much smaller space, and form only an insulated patch, surrounded by the weald clay, which passes into the interior from the shore beneath the village of Sandown, and in returning to the sea divides the cliff, about midway between the fort and Culver, and immediately on the west of Red-cliff. The whole of the intermediate tract between the two chalk ranges, from New Church, through Godshill, and thence to Kingston, is probably occupied by the Green-sand alone,—except perhaps in the deepest places, where the weald clay may appear in the beds of the streams.

III. The strata then, of which the south of the Isle of Wight consists, are the following:—

	Names given by Mr. Webster.
1. Chalk	Chalk and chalk marl.
2. Sandstone, with chert, &c. (*Firestone*)	Green sand.
3. Clay (of the undercliff) (*Gault*)	Blue marl.
4. Sand, with various fossils (*Greensand*)	Ferruginous sands.
5. Clay (of the wealds and Tetsworth)	
6. Sands (of Hastings) the lowest beds in the island	

I cannot give a full description of these beds, but the following observations may assist for the purpose of recognising them, where the order is less distinct than in the Isle of Wight: more detailed sections, accompanied by specimens, have been laid before the Geological Society. The shells which I shall mention have been named by Mr. Sowerby, who will give figures in his Mineralogical Conchology, of such as have not already appeared.

Firestone.—This formation is obviously of such importance as to require a distinct name; and it seems better to adopt that which I have given, than to retain the term *green-sand* employed by Mr. Webster, which has been almost universally appropriated to a lower stratum; the *Firestone*, of Ryegate &c. exhibiting a sort of average character, between that of the lower part of the Cambridge *Chunch*, and of the greener beds of the Isle of Wight. The formation in the latter place has been so well described by Mr. Webster, (p. 140.) that I need only mention the importance of extending the list of its fossils, for the purpose of more completely distinguishing it from the lower beds of the green sand, with which it has been frequently confounded.

The Firestone holds its place, and is visible every where along the coast of Dorsetshire, as far as Whitenore Point, where the chalk retires from the sea; and it exhibits the same characters throughout. It can also be traced through the greater part of Sussex and Surry; but in Kent seems gradually to become less conspicuous, and to lose some of its more prominent characters as it approaches the sea, on the east of Godstone. There can, I believe, be no doubt of its geological identity with the lower part of the Cambridgeshire *Clunch*:* The fossils, so far as they are known, are nearly the same in both;—and they are in both cases different from those of the green-sand.

Gault.—Clay of the Undercliff.—Either of these denominations for the marly clay, which immediately succeeds the firestone, appears preferable to that of *blue marl*, which is taken from a character neither constant nor peculiar to this stratum; and all the evidence that I have had an opportunity of examining, is in favour of its identification with the Cambridgeshire gault, and the blue marl of Folkestone; the principal difference, which certainly is remarkable, consisting in the great abundance and variety of the fossils at the place last mentioned, and their comparative rarity in the clay beneath the Firestone of the Isle of Wight. Mr. Webster has mentioned this peculiarity, and though I searched carefully in various parts of the island, I could not find any of the more characteristic Folkestone shells; the place of the bed, however, is not only remarkably well defined along the whole southern coast, but is plainly discernible also to the west, as far as Durdle Cove. Its characters in all these places are very uniform: the clay being of a dull bluish grey colour, harsh to the touch, adhering not very strongly to the tongue, and containing numerous minute glittering particles, which have been taken for mica, but which I believe are more frequently crystalline plates of gypsum,—distinct crystals of that substance being found in it in great abundance, originating probably in the decomposition of the pyrites,† which it every where contains. It effervesces strongly with acids, and besides the shells, which (in the Isle of Wight) are dispersed through it in small numbers, frequently exhibits traces of slender cylindrical ramifications, probably derived from organized bodies. The fossils which I succeeded in preserving (for in general they are very fragile), are the following:

* See Hailstone and Warburton, Geol. Trans. vol. iii. pp. 248—250.

† The specimens, however, have been generally taken in places where the clay has been long exposed to the action of air and moisture: its characters may be different when freshly opened, at considerable depths from the surface. Mr. Aikin has informed me, that at the Highgate Tunnel, the London clay when fresh dug out was uniform, soft, and saponaceous to the touch, not containing any crystalline particles; but after exposure for a few weeks to the air, the surface was found to be covered more or less with small rhomboidal crystals of gypsum.

Mya mandibula.—(Min. Conch. Plate 43.)
Corbula pisum?—(Ibid. Plate 209, fig. 4.)
A thin shelled bivalve: perhaps a pecten.
A very thin shelled ammonite.
Scales and bones of a fish.

The Gault has, in the Isle of Wight, been sometimes confounded with the weald clay; from which, however, it is distinguished by several internal characters, and is every where separated by the stratum next to be described.

Green Sand.—This term, although objectionable as being derived from a character, which is not only variable, but in reality does not belong to the greater part of this stratum,—has been adopted so very generally by the geologists of England, that it seems almost necessary to retain it;—keeping always in view the great occasional variance between the name, and the true character of what it is intended to signify.

Mr. Webster's description of what he has named ferruginous sands, relates almost exclusively to this stratum; for he has but slightly noticed the inferior (Hastings) sands, and considers the intervening clay as of subordinate importance: with these exceptions, his descriptions are very instructive.

The upper part of the series is principally distinguished by an abundance of ferruginous matter; some of the beds appearing to consist, in a great measure, of particles of brown hematitic iron ore, the surfaces of which are highly polished, mixed with a somewhat coarse quartzy sand. These are especially remarkable in the red cliff near Culver, and in the corresponding elevated beds at Compton Chine. Near the top of the formation also, some of the sandy beds are of a very dark colour; probably from an intimate admixture of carbonaceous matter, for the specimens become whitish on being heated, without any bituminous smell.

In the lower portion, calcareous matter occurs in greater quantity; and though traces of organic bodies, especially of those allied to Alcyonia, occur throughout the formation, it is principally from the lower beds that the shells described as belonging to it have been procured; and these beds also particularly abound in green particles. The characters of the whole series are fully displayed on the shore of Sandown Bay; the ferruginous portion appearing in the most striking form at Redcliff, and the lower beds on the shore immediately to the east of Shanklin, between the Chine and the Village of Sandown;—where among the debris fallen from the vertical cliff specimens may be found of almost every variety of green sand, from a calcareous rock resembling the Kentish rag, to a stone composed almost exclusively of green particles. The upper and more ferruginous beds correspond, I believe, with what is called *Carstone*, at Hunstanton, in Norfolk; and the contrast between the different parts of the formation is conspicuous in various parts of

Surry and Hampshire:—so that Mr. Conybeare's description of the green-sand between Leith Hill and Dorking,—where the more ferruginous beds are stated to appear 'like a second formation of iron sand resting upon the green sand,'* is most correctly applicable also in the Isle of Wight.

One of the most remarkable of the lower beds of this formation seems to occur at the very bottom of it, and is indeed detached from the superior strata, by a group which forms, as it were, a transition to the weald clay; consisting of greenish grey sand in very thin beds, intimately mixed with a small proportion of clay, and of bluish slaty clay. This detached bed is itself composed of large irregular concretions of greenish sand, with much calcareous matter, and contains numerous petrifactions. It rises about 1000 paces from the chalk in Sandown Bay, and may be traced upwards in the face of the ruined cliffs on the west of Red cliff. The same fossils abound also on the shore to the east of Shanklin Chine, and in a bed which rises on the west of the central chalk, and may be traced from Walpen Chine to Atherfield Point. It is, probably, from the corresponding part of the series in Surry and Sussex, that a great many of the green sand fossils of those counties will be found to have come: several of the shells found near Ashford, in Kent, and at Parham Park, in Sussex,† being the same with those of the vicinity of Shanklin, &c.

One feature of this formation, which is very conspicuous on the coast of the Isle of Wight, and might lead into error in situations less favourable for examination, consists in the great variation of aspect and solidity in different portions of the same continuous beds; one part not unfrequently appearing as a very dark greenish, or almost black, sandy clay; while the very same bed has in other places, where the fracture is recent, a bright reddish and yellowish hue. This appearance has been noticed by Sir H. Englefield and by Mr. Webster, and is ascribed by them, I believe correctly, to the effects of moisture and exposure, on the variable proportion of clay and ferruginous matter which the beds every where seem to contain.

The greater part of the fossils assigned to the Iron sand, in Prof. Sedgwick's valuable paper on the Isle of Wight, belong to the lower part of the green-sand formation.‡ I have

* Outlines, p. 154. † See Mantell, p. 71, &c.

‡ *Annals of Philosophy*, May, 1822, p. 329, &c. They are as follows:—

Cylindrical concretions, probably from organized bodies,
Stems of the tulip alcyonium,
A compound madrepore,
An obscure coralline body,
Vermicularia,
Ammonites,
Rostellaria,
Casts of three or four other univalves,
A palmated cockscomb oyster,
Trigonia dædalea,
T. alæformis,
Astarte excavata?
Sphæra corrugata,
Terebratula pectita?
Perna aviculöides?
Gryphæa sinuata.

The other fossils of Prof. Sedgwick's enumeration belong to the Weald clay. The

found in it, besides those contained in that list, the following:—

A crustaceous animal, about the size of a small shrimp; near Atherfield.
Serpula, two species; from the same place.
Corals; probably of different species.
Ostrea Bellovacina? (Min. Conch. Plate 388, figs. 1 and 2.) East of Shanklin.
Terrebratula, two species; Atherfield Point.
Gervillia ————? Shanklin.
A murex.
Another univalve.

Weald Clay.—The clay of this formation, both at the top and bottom, seems to be mixed with a considerable portion of sand. It contains within it at the upper part an insulated bed of green sand; and, about an equal distance from the bottom, a bed of sand rock, which may be considered as the forerunner of the Hastings sands: but the central portion is very well characterised, and the formation may be traced distinctly in its proper place, all along the southern coast of the Isle of Wight: nor does any clay, at all approaching to it in characters or thickness, occur between the Gault and the Purbeck series. The first beds appear to rise on the east of Sandown Bay, about 1000 paces from the junction of the chalk with the firestone beds; the formation occupies a considerable space in the ruined cliffs which succeed the precipice of Red-Cliff; but the land-falls at this place render it difficult to trace the beds in continuity, and on the shore below the clay is in general concealed by the gravel of the beach:—nor is it again visible till, after giving place to the small portion of the Hastings sands disclosed there, it recurs in the flat space to the west of the fort; where, at very low tides, beds of clay may be seen upon the shore beneath the inn at Sandown village, sinking to the westward under the prolonged cliffs of the green-sand between that place and Shanklin. The clay rises again from beneath the green-sand on the west of Whale Chine, between Atherfield-high-cliff and Atherfield Rocks,—where the bed of green sand included in the upper part is very distinct, and rich in a great variety of fossils: and from thence for about a mile westward, the cliffs afford a most instructive section of the weald clay,—perhaps the best that can be found in England;

moulds of several of these shells (and, perhaps, others) which appear to have been occupied by pyrites, occur together, in remarkable ferruginous nodules, which are found in the upper part of the cliff immediately on the west of Shanklin Chine, and in the corresponding place within the chine itself.

the shore being divided by two considerable ravines, or chines, which greatly favour the examination of it.*

The uppermost part of this formation, on the confines of the green sand, consists of bluish-grey sand and clay, in very thin alternating courses, frequently not more than a-tenth of an inch in thickness, or of fine greenish grey, mottled with lighter coloured sand; the lighter portion sometimes occupying what appear to be the moulds of minute ramified organic bodies, which exist in great numbers, but are indistinct in all the specimens that I could obtain. These upper beds are, altogether, perhaps thirty or forty feet thick. They are succeeded by the bed already mentioned as the last of the green sand series; and this is immediately followed by a considerable thickness of slaty clay, which varies in hue and consistency, but is in general of a dark bluish grey colour, smooth to the touch, scarcely adhering to the tongue, yielding very easily to the nail, and effervescing with acids. The laminæ of this clay are coated with the remains of a minute bivalved crustaceous animal, the *Cypris faba* of Desmarest,† in vast profusion; and it contains also various shells.

In the clay, there occur subordinate beds of lime stone;‡ some of which are from five to nine or ten inches in thickness, consisting principally, of bivalves, probably cyrenæ,—and containing also a small Paludina; one at least of these beds is coated with a thin, somewhat fibrous crust of impure greyish carbonate of lime, approaching that which in a more distinct form occurs between the beds of the Purbeck limestone;—to which indeed this limestone of the weald bears altogether a very striking resemblance. Another bed of limestone consists almost entirely of a small species of oyster, retaining its shelly lustre. And a third variety must also exist in this formation, either in the form of a bed, or of concretions, though I could obtain only portions of the latter description scattered on the shore;—but these were numerous, and had evidently come from the immediate neighbourhood: they consist of sparry limestone almost wholly made up of casts of a Paludina, closely resembling the P. vivipara (Sowerby, Min. Conch. Pl. 31), and are scarcely to be distinguished from some varieties of the Bethersden stone of Kent. This same stone at Sandown Bay contains also casts of the Cypris faba, so abundant in the slaty clay; and I have had since the satisfaction of finding that remarkable fossil in almost all the specimens of Sussex marble,

* The state of the weather was so unfavourable, during my visit to this place, that the following characters have been taken principally from the beds at Sandown Bay.

† Hist. Naturelle des Crustacés Fossiles, p. 140, Pl. XI. fig. 8.

‡ This shelly limestone is known in the neighbourhood of Chale Bay by the name of the "Platnor stone," or "Black lake," or both; for some of my informants applied the former term to the slaty clay.—The resemblance of the calcareous incrus-

which I have had an opportunity of seeing:—its occurrence indeed in that of Petworth has been long since mentioned by Mr. Sowerby, in the description of his plate of the Vivipara (Min. Conch. Pl. 31, vol. i. p. 78), though it seems to have escaped attention, as a fossil of this formation.

Subordinate to the clays, especially in the lower part of the formation, are also several beds of clay iron stone, some of which contain, disseminated, the same species of cypris as that of the shale, and also in considerable abundance, the casts of a species of Paludina (elongata), which seem to have been filled with pyrites; one of these beds at Sandown Bay was remarkable in having attached to it irregular concretional masses of a hard calcareous grit, containing numerous casts of a Paludina, filled with lamellar sulphate of barytes.* Towards the bottom of the formation, very thin courses of a hard calcareous grit alternates with greyish clay; and below them is a bed, from ten to twenty feet in thickness, of sand rock or slightly coherent sand, of a light greenish grey colour, but in some places ferruginous, containing concretions of grey calcareous grit; this bed, the forerunner, as it were, of the iron sand, is insulated in the clay,† and is followed by thin beds of mottled greenish sand, containing a small proportion of clay, and of blue clay; the whole about forty feet in thickness. And these are finally succeeded by sand rock, containing a large proportion of concretional calcareous grit of a greenish hue,—the commencement of what may be considered as the proper Hastings sands; after which no more blue clay appears.

The succession of the beds, near Atherfield Point, where they are best displayed, seemed to me to resemble that above described; and the fossils there were the same with those of Sandown. In Compton Bay, the section is perplexed by a considerable subsidence, or perhaps a fault; which after the first rise of the iron sands, brings down the weald clay again to the shore, so as to produce the appearance of an alternation:—but the order of the beds, and the fossils they afford, are still the same.

The following are the fossils which I have found in this formation in different places:—The concurrence of the vivipara and cypris, in such great abundance, with several other shells in no

tation to the Curl (or "Cone in Cone") of Staffordshire, &c. is mentioned by Prof. Sedgewick (*Annals of Philosophy*, vol. iii. p. 342); and there appears to be a gradation, from the indistinctly fibrous incrustations of this place, to the highly crystalline fibrous carbonate of Purbeck.

* My attention was directed to this fact, and to the occurrence of the crystals of sulphate of barytes in the fuller's earth of the Nutfield green-sand, by Mr. Sowerby.—I have myself a specimen of crystalline sulphate of barytes, with carbonate of lime, from the firestone beds of Worbarrow Bay; so that this mineral appears to be generally, though sparingly, diffused throughout these formations.

† It is not impossible that the occurrence of this or similar detached beds of sand rock, within the lower part of the weald clay, may have occasioned obscurity, where the state of the surface prevents their relations from being perceived.

small quantity, may tend to supply a geological desideratum of some importance, by furnishing distinctive characters for the weald clay, which hitherto it has not been easy to recognize in doubtful situations.

Cypris faba. (Brongniart and Desmarest. Crustacés, p. 141. pl. xi. fig. 8.)—*Hythe.—Bethersden.—Petworth.—I. of Wight.—Swanage Bay* (see hereafter, p. 382).
Cardium turgidum? (edge toothed). Min. Conch. pl. 343.—*I. of Wight.*
——— a larger species (edge plicated).—*Swanage Bay.*
Cyrena media (a new species).—*I. of Wight.—Swanage Bay.*
——— a larger species.—*I. of Wight.—Swanage Bay.*
——— membranacea?—*Swanage Bay.*
Melania attenuata.—*Swanage Bay.*
——— tricarinata.—*I. of Wight.—Swanage Bay.*
Paludina elongata.—*I. of Wight.—Swanage Bay.*
——— fluviorum. Min. Conch. pl. 31.—*Bethersden—Petworth.—Sandown Bay.*
Pinna?—*Swanage Bay.*
Venus?—*Swanage Bay.*
A short univalve, like a Helix.—*I. of Wight.*
A transversely elongated, almost cylindrical bivalve.—*Swanage Bay.*
Tooth of a Crocodile.—*Swanage Bay.*

The following are mentioned in Mr. Sedgwick's paper already referred to:—

Ostrea; an undescribed species, somewhat resembling O. tenera. Min. Conch. pl. 252. fig. 2 & 3.—*I. of Wight.*
——— a small flat species?—*I. of Wight.*

The only other place in which the Cypris is stated to have been found in a fossile state, is in the Department of the Allier, in the south-east of France; where it occurs in the greatest profusion, and is mentioned by Brongniart* as composing almost exclusively the mass of a coarse fresh water limestone—(calcaire lacustre). In another part of the same district, land and freshwater shells were observed, and veins of fibrous arragonite, but without the cypris: and Mr. Brongniart considers the whole tract as of freshwater origin. The occurrence of a fossil hitherto so rare as the cypris, in such profusion, in counties so distant from each other, is remarkable; and renders it very desirable to determine the geological relations of the strata where it has been found in France.

Hastings Sands.—The terms 'ferruginous' and 'iron sands,' denote a character that really belongs to the upper portion of the green-sand; and the former has been applied by Mr. Webster to a series which includes three strata at present known to

* Description Geologique des Environs de Paris.—Cuvier ossemens fossiles, &c tome ii. Edit. 2de, p. 536.

be distinct: It may be advantageous, therefore, to relinquish altogether both of these denominations, and to adopt one from a place where (as at Hastings) the strata are well developed and conspicuous. Names thus derived, do not mislead; they keep in view and facilitate reference to the original type, and have in fact been adopted for some other strata,—as the Purbeck, and Portland limestones, the Oxford clay, &c.

The Hastings sands in the Isle of Wight may be described as consisting of an alternating series of beds of sand,—more or less abundant in ferruginous matter, and containing courses generally in a concretional form, of calcareous grit,—with beds of clay, much mixed with sand, of a greenish or reddish hue, or of a mottled and variegated appearance. Subordinate beds containing or consisting of fuller's earth, occur along with these clays;—and wood more or less changed, wood-coal, and iron stone, occur in several parts of the series. In the Isle of Wight a part only of the formation is visible: but at Swanage, a section of the whole is exposed; and in both cases, the proportion of the clays to the more prominent sandy beds is so great, that if composition only were regarded, the formation ought to take its name from the former. In this respect the sands of Hastings differ considerably from the upper part of the green sand series, which contains much less clay; nor do any of the Hastings beds at all resemble those sands at Red Cliff and Compton Bay, which abound so remarkably in particles of iron ore. There is also a more general difference of hue and aspect, between the greater part of the Hastings strata, and the richly coloured sands in the upper part of the green-sand, which can be recognized, I think, by an eye acquainted with both; but the difference between the fossils of the two formations is fortunately so great as to afford a much more certain distinction.

The section of this formation visible in Sandown Bay, though of small extent, resembles perfectly that of the opposite side of the island, between Cowleaze and Compton-Grange Chines. The prominent land on the west of Southmore, (called, not very correctly, Southmore Point,) is the central part of the series, and the beds thereabouts are the lowest in the island; the section of them on the shore from Bull-rock to Brook Chine, being a very flat curve, declining on both sides towards the chalk:—but an appearance of greater curvature than really exists is occasioned by the projection of the land, and the gradual rise of the beds from the interior. The principal variation in the features of this part of the coast, is produced by the successive rise of the beds of sand rock with calcareous grit; which, as the clays between are much less durable, form ledges extending considerably into the sea. It is to the

superior solidity of these beds,—the bony skeleton as it were of the formation, that its resistance to the denuding forces which have swept away such large portions of the adjacent clay, must be ascribed, in the wealds of Kent and Sussex, and on a smaller scale in the Isle of Wight.—Thus the bed, called the "upper sand rock," which rises very gradually near Cowleaze Chine, may probably have contributed to the support of Atherfield Point; and the successive ledges of Barnes's sand rock, Ship ledge, the Bull rock (about 20 feet in thickness), and the very remarkable ranges at Brook Point, all owe their prominence and solidity to a concreted calcareous grit, precisely resembling that of Hastings; at which place also reefs of the same description occur upon the shore. In Swanage Bay four or five reefs, consisting of the same kind of rock, run out from the sands into the sea; and even at Sandown Bay, a few such ledges can be seen at very low tides.

The grit is, in all these cases, of the same general character, and is evidently nothing more than sand agglutinated by a calcareous cement which has crystallized within it; so that in a certain stage of decomposition, a double structure is discernible, the masses of stone becoming fissile so as to disclose the original stratification of the sand, while the fresher pieces show the crystalline fracture of carbonate of lime; and in some cases the parallel faces of the crystals distributed through the mass give by reflection the lustre of carbonate of lime, from a surface which, in other positions, appears to be composed of grains of sand. In the Isle of Wight, the varieties of grit are numerous, and of various shades of grey inclining to blue and green. They all effervesce with acids; but differ considerably in hardness, probably from variation in the proportion of siliceous matter.

The only fossils that I have found in the Hastings' sands and limestones, belonging also to the weald clay. I have added to the following list a few others, from the beds of clay and limestone below the Hastings sands, in Sussex.

Cypris faba.	In calcareous grit; at Hollington, near Hastings.
Paludina lenta?—smaller and more pointed than P. fluviorum	
Cyrena media	
Cyrena media	In calcareous grit; between Battle and Brightling, Sussex;—and Brook Bay, Isle of Wight.
Cyrena, a larger species.	
Remains of fishes.	
Remains of plants.	

From the beds below the Hastings' sands, north-west of Battle, Sussex.

Cyrena media	In slaty clay between the beds of limestone, near Darvel Wood.
A thin elongated pearly bivalve like a compressed muscle.	
Potamides ventricosus? (M. C. 341. f. 1)	
Vertebra of a crocodile	

Scales (of a fish?) large, quadrangular, imbricated : in lime stone, from the same place.

A comparison even of this short list with that of the green sand fossils, points out a distinction between that formation, and the Hastings sands, which may, perhaps, deserve attention, in the grouping and arrangement of the strata :—the organized productions of the former, so far as we are acquainted with them, being all marine : but of the latter, almost exclusively of fresh-water origin. And in fact if a line be drawn between the green sand and weald clay, the whole series, from thence downward to the Portland limestone, may be regarded as one great suite of fresh-water formations :—with the exception principally of those beds of oysters which occur, in small proportion in the weald clay, and more remarkably about the middle of the Purbeck strata,—where a bed, about twelve feet in thickness, well known to the quarry men under the name of " cinder," consists almost entirely of oysters.

The resemblance observable in the Isle of Wight, between some of the beds above the chalk and some of the Hastings sands, seems to favour the hypothesis, of the mixed origin, at least, of the latter. The light greenish grey and variegated clay of the two series, are very much alike; and among the fossils some of the most abundant in both are of the genus Paludina. The calcareous grit also is not without a parallel in the superior beds; for the stone of East Cowes quarries, which is there called 'rag,' comes very near to some varieties of the Hastings' grit;* and among the freshwater shells which it contains is a helix resembling the vivipara.—But, on the other hand, some of the Hastings sand beds are scarcely to be distinguished from those of the new red sand-stone (red marl).—This recurrence of beds of the same character, in parts of the series which we are in the habit of considering as so remote, should never be lost sight of; as affording proof of that uniformity in the operation of the causes which have produced the strata, which the

* When I visited this place, the pits in Lord H. Seymour's grounds had been filled up, but the specimens I found there were sufficient to shew this resemblance.—See Webster: Letters, p. 231.

artificial divisions of scientific arrangement not unfrequently keep out of view.

The Wealds.

IV. The coast section between the chalk cliffs near Folkestone, and Beachy Head, is so much concealed by marshy tracts throughout the portion corresponding to the place of the green sand and weald clay, that the examination of it is difficult and unsatisfactory; but I have coloured the section (fig. 1), in conformity with that of the Isle of Wight,—in part from observations of my own, with the hope of suggesting further inquiry; since there is strong reason to expect, from the perfect correspondence of the interior, that the arrangement of the beds upon the coast also, will prove to be throughout the same.

At Beachy Head there is no difficulty, the chalk being there succeeded by, and almost passing into beds of firestone, of inconsiderable thickness, but corresponding to those of Culver, &c. in the Isle of Wight, and of Ryegate, in Surrey:* these are followed by blue clay, harsh to the touch, somewhat sandy, and apparently containing few fossils. From thence to a considerable distance eastward, the strata are concealed; but there can be little doubt that the low sand hills which occur at Langley, and from thence run inland through Arlington, Selmeston, &c. (Mantell, p. 76), in a line nearly parallel to the chalk, belong to the green-sand formation.

Mr. Smith's maps of the interior, and his section from London to Brighton, accord with this identification. The list which he has given of the beds within the denudation of Kent, Sussex, and the adjoining counties, corresponds exactly, though under different names, with that of the section, fig. 1; and the range of "sand and sandstone," represented in his map of Sussex as passing through Barcombe, is obviously the continuation of the sands of Langley above-mentioned.

The shore on the east of Beachy Head, nearly to Bexhill, is so low and flat, that the beds can be examined only (under favourable circumstances) at low water; the Hastings sands, however, rise about the latter place, and the upper part abounds with reddish and greenish clays, like those already described as forming so large a part of this formation in the Isle of Wight.† The sands decline to the eastward, and subside about Stone Cliff on the east of Rye, and there again the country becomes difficult of examination; what may be considered as the true coast being separated from the sea by Romney Marsh. But the character-

* The firestone at Sea-houses has been generally taken for green-sand, and supposed to represent the ridge between the chalk and iron sand of Kent and Sussex, which begins at Folkestone and Hythe. (Conybeare, Outlines, p. 147).

† The cliffs at Hastings have been fully described by Mr. Webster, in a paper read before the Geological Society. See *Annals*, July, 1824, p. 66 of this volume.

istic fossils completely identify the limestones of that tract with those of the Isle of Wight; and there can be no doubt as to the place where the formation commences, the Cypris faba being found in the clay immediately beneath the green sandstone, above the town of Hythe.

In pursuing the boundaries of the chalk around the great denudation of Kent and Sussex, the same succession of beds can be recognized in several other places.—Thus the description given by Mr. Mantell, from Mr. J. Hawkins, of the 'Malm rock' of Western Sussex, accords with the succession represented in Sections 1 and 2. A similar section has been communicated to me by Mr. Lyell, from the village of Shiere, between Dorking and Guilford, on the north western side of the weald district: the following being the order of the beds,—chalk, green sand with calcareous chert (firestone); blue marl (gault) of dark colour, with a few fragments of shells; and ferruginous sand (the upper beds of the green sand).—The section (fig. 1), it will be seen, corresponds essentially with that given by Mr. Webster,* and by Mr. Phillips ("Outlines," p. 150, &c.) of the tract between Merstham and Nutfield, in Surry.—And Mr. Warburton informs me that he has traced the upper ferruginous portion of the green-sand eastward,—from Guildford through Red-Hill (Ryegate), River-Head, Seal, Ightham, and Wrotham Heath, to Aylesford, in the neighbourhood of Maidstone.

On the east of Godstone however, the structure of the county must still be considered as, in some degree, uncertain, for the following reasons: 1. That the firestone beds have not been traced to the west of the point above-mentioned; though their equivalent will probably be found among the harder beds at the bottom of the grey marly chalk. 2. Notwithstanding the many evidences of correspondence,—the great abundance of fossils in the Folkestone marl, and their comparative scarcity throughout the Isle of Wight, is a variation of such amount as to demand the strongest evidence of geological identity.† 3. The ferruginous beds at the top of the green-sand formation, have not yet been observed in the vicinity of Folkestone; while on the other hand, calcareous matter exists there in much greater proportion than in any part of the lower beds in the Isle of Wight:—The fossils, however, are the same. But I have observed some appearances on the shore between Sandgate and Folkestone,

* Geol. Trans. vol. v. p. 353.

† On the opposite coast of France, the Folkestone marl occurs beneath the chalk without the intervention of the fire stone, at least in a prominent form. I have traced it with most of the characteristic shells of Folkestone, all round the denudation of the lower Boulonnois, from the foot of Blancnez, through Boursin, Colemberq, Lottinghen, &c. to the vicinity of Samer; and have found in several places beneath it traces of green sand.—In Mr. Smith's maps of Kent and Surry, the gault is continued, without interruption, from the west of Dorking to the coast.

which seemed to render this part of the series deserving of further examination.

Coast of Dorsetshire.

V. The progressive condensation, and thinning out of the strata towards the west,* is such, that the space occupied by the beds between the chalk and the lowest visible part of the Hastings sands,—which is in Sussex (from Folkestone to Winchelsea, fig. 1),—more than twenty miles in extent,—is reduced successively;—in the Isle of Wight (between Rocken-End and Southmore), to about eight miles;—at Swanage Bay, fig. 3, to less than one mile and a half;—at Worbarrow, fig. 5, to less than three-quarters of a mile; and finally at Durdle Cove, fig. 6, where these beds appear, for the last time, on the coast, to less than a furlong:—the horizontal distance in a direct line between Folkestone and Durdle Cove, the extreme points of this series, being about 170 miles. This convergence, it is true, appears much greater than it actually is, in consequence of the high inclination of the strata on the coast to the west of Purbeck, where at last they become very nearly vertical;† but the condensation is really sufficient to make it more extraordinary that so many members of the series have been retained, than that some beds should be wanting.

At Worbarrow, and in the coves to the west of that place, I could not detect any trace of the weald clay, between the sands below the gault; the sections (fig. 5 and 6) affording only one continuous series of sandy beds, from the gault to the commencement of the Purbeck strata. But at Swanage (fig. 4 and 5) I was more successful, having found there distinctly the equivalent of the weald clay;—beds of bluish slaty clay containing the cypris faba, and other shells of the same species with those of the Isle of Wight; and limestone in thin strata, composed of bivalves, with small paludinæ, and of oysters, and in some cases encrusted with obscurely fibrous carbonate of lime. Beds, also composed of mottled greenish-grey sand and grey clay, like those of Sandown and Cowleaze chines, occur in this part of the section.—But the sands interposed between the weald clay and the Gault are not in themselves distinguishable, at Swanage Bay, from the inferior (Hastings) beds; the green particles being wanting, and the sands differing only in colour, fineness of grain, and a variable admixture of clay. There are among them some remarkable courses of a very fine grained calcareous grit used by the Swanage quarry-men for sharpening their tools: but I have not

* See Webster, Letters, p. 194, and Plates.

† The difference as to the impression produced on the observer, by beds of the same thickness when nearly horizontal, and when highly inclined,—which arises from our habit of estimating heights and horizontal space by very different scales, deserves the attention of those who are not much accustomed to geological observation. Thus a bed, or group, 200 feet thick, if horizontal, forms a very striking cliff; but as part of an highly inclined series, it may be passed by with comparatively little notice.

yet had an opportunity of comparing the specimens, with those of the Whetstone quarries at Blackdown, in Devonshire, which are in the green sand.

Fig. 3, is a section southwards from the chalk near this place to the town of Swanage, but reversed, for the purpose of showing its correspondence with that of the Isle of Wight at Compton Bay: and I have also copied a portion of Mr. Webster's accurate view of the coast, for the purpose of pointing out more precisely the situation of the clays.*—In this sketch (fig. 4) the spectator is supposed to be placed upon the firestone where that bed first rises from under the chalk, and to look along the shore towards Swanage. Masses of fallen chalk are seen between this place and the commencement of the Hastings sands:—but these are easily accounted for,—being in fact an undercliff, produced exactly in the same manner as in the Isle of Wight:—and the firestone and gault rise and hold their place with as much regularity as I have any where else remarked.

The section of the Hastings sands, in Swanage Bay, comprehends the whole of the formation, and gives one of the most distinct views of it that can be obtained in England. It corresponds completely, at the upper part, with the beds which are visible in the Isle of Wight, and at Hastings.

VI. Very little is yet known of the strata which form the subject of this paper, in the interior of England; but an attentive perusal of Mr. Conybeare's descriptions will show that some of the obscurities connected with them, may be resolved by referring to the order in which the beds are exhibited in the Isle of Wight. I am in fact unwilling to abandon the expectation of finding in this part of the series the same steadiness of arrangement, that is known to exist in other portions of it: the reasoning which implies, that less of regularity is to be expected in a suite of sands and clays than elsewhere, having always appeared to me to be insufficient. It is the fact alone, established by extensive observation, that could have rendered credible the identity and constancy of succession of any portion of the strata; and we really know so very little of the mode in which they have been formed, that our estimate of the comparative probability of regularity in one description of beds, of sand, or clay, or limestone, more than another, is matter of the very slightest conjecture.

* The place where all the beds above described occur is called Punfield. The examination of it is rendered difficult by the position of the strata, which retire obliquely inland, and at the same time, when seen from the shore, rise towards the eye; so that the weald clay lies behind the upper beds of the Hastings sand, in a nook, where it is so much obscured by the fall of the incumbent substances, that without the assistance of quarry-men I could not have obtained a view of the beds in situ.

Article XII.

SCIENTIFIC NOTICES.

Chemistry.

1. *Juice of Elder Berries as a Test.*

The juice of the elder berries seems to possess important properties as a delicate reagent. The following process was employed:—

Take any quantity of the ripe berries, picked clean from the stalks, and after having bruised them, press the juice into a clean well-tinned vessel. Add a fourth part of its weight of alcohol, and evaporate the mixture to one-half. Remove it from the fire for ten or twelve minutes, and add as much alcohol as you have of concentrated juice. A copious precipitation of the parenchymatous and gummy parts will take place, which will permit the liquor to be strained with ease through a fine cotton cloth.

The filtered liquor is now fit for use. It consists of the saccharine and colouring principles of the berries, in solution with alcohol and water. It is of a beautiful violet colour. In order to ascertain its utility as a test of acids and alkalies, the following experiments were made:—

To one pint of rain water a single drop of the tincture of elder berries was added. The blue colour was too pale to be perceived; but the addition of a single drop of sulphuric acid produced a decided red colour.

To the liquor employed in the last experiment, a minute quantity of alkali was added, when it immediately changed to a bright lively green. If a quantity barely sufficient to neutralize the acid be employed, the original blue or violet colour is restored; hence this test possesses all the delicacy of the tincture of litmus, or blue cabbage, and has this additional valuable property of keeping unaltered, during the hottest season of the year. The species tried as above was the *Sambucus canadensis;* the juice of the common elder berry (*Sambucus nigra*) will probably answer as well.—(Annals of the Lyceum of Nat. Hist. of New York.)

2. *Volatility of the Salts of some of the Vegetable Alkalies.*

Ferrari states that all the salts of Strychnia, when dissolved in water, are volatile in temperatures below that of boiling water. The volatilization is most considerable when the solution is concentrated, and when it contains an excess of acid. The salts which he examined were the sulphate, muriate, nitrate, and acetate. He remarked also that the muriate of chinin is so volatile that the steam which rises from its aqueous solution in a

state of ebullition, has a decidedly bitter taste. The volatility of the sulphate of chinin had been previously taken notice of by Callaud.—(Giornale di Fisica, &c. vi. 457.)

3. *Existence of Manna in the Leaves of Celery.*

Dr. A. Vogel finds the following substances in the leaves of this plant (*Apium graveolens*).

1. A colourless volatile oil, in which resides the peculiar odour of the plant.
2. A thick fatty oil, partly combined with chlorophyle.*
3. A distinct trace of sulphur.
4. A tremulous jelly, or bassorine, which acquires a gelatinous consistency, by the action of weak acids or of water.
5. A brown extractive matter, soluble in alcohol, and precipitated by solutions of tin and lead.
6. Gum.
7. Manna.
8. A very considerable quantity of nitrate of potash.
9. Muriate of potash.

The manna may be extracted by boiling the filtered juice of the leaves in order to precipitate the chlorophyle and vegetable albumen, and evaporating the liquid thus purified, to the consistency of honey: it separates on cooling in greyish white acicular crystals. But the most accurate procedure is to digest this thick liquid for a few minutes in alcohol, and to filter the solution while boiling hot. After some hours it concretes into a soft white coloured mass, resembling a cauliflower: this may be rendered considerably purer by squeezing out the alcoholic liquid, redissolving the solid portion, and crystallizing a second time.

Thus obtained, it possesses all the properties of manna purified by solution in alcohol. Like this, it has a sweet taste, is very soluble both in cold and hot water, dissolves but sparingly in cold, and to a large amount in hot alcohol, and on cooling separates from the solution in the form of a soft white mass, resembling a mushroom. The solution also is quite incapable of the spirituous fermentation.

The fresh leaves of celery yield rather more than one per cent. of manna, purified by repeated crystallization.

He could not succeed in detecting a trace of manna in the leaves of common parsley (*Apium Petroselinum*), or of the common leek (*Allium porrum*).

This is the first well authenticated instance of manna occurring in the leaves of an European plant.—(Schweigger and Meinecke's Jahrbuch der Chemie und Physik, vii. 365.)

* This is the name which Pelletier and Caventou have applied to the green colouring matter of leaves, and which would appear from their experiments to be a peculiar vegetable principle.—(See Journal de Pharmacie, iii. 486.)

4. *Iodous Acid.*

Il Sig. Sementini, of Naples, has published an account of a combination of iodine and oxygen, containing less of the latter principle than iodic acid. It is obtained in the following manner:—Equal parts of chlorate of potash and iodine are to be triturated together in a glass or porcelain mortar, until they form a very fine pulverulent yellow mass, in which the metallic aspect of the iodine has entirely disappeared. If there be excess of iodine, the mixture will have a lead colour. This mixture is to be put into a retort, the neck being preserved clean, and a receiver is to be attached with a tube passing to the pneumatic trough. Heat is then to be applied, and for this purpose a spirit lamp will be found sufficient; at first a few violet vapours rise, but as soon as the chlorate begins to lose oxygen, dense yellow fumes will appear, which will be condensed in the neck of the retort into a yellow liquid, and run in drops into the receiver; oxygen gas will at the same time come over. When the vapour ceases to rise, the process is finished, and the iodous acid obtained will have the following properties:—

Its colour is yellow, its taste acid and astringent, and leaving a burning sensation on the tongue. It is of an oily consistency, and flows with difficulty. It is heavier than water, sinking in it. It has a particular odour, disagreeable, and something resembling that of euchlorine. It permanently reddens vegetable blues, but does not destroy them as chloric acid does. It is very soluble in water and alcohol, producing amber-coloured solutions. It evaporates slowly, and entirely in the air. At 112° Fahr. it volatilizes rapidly, forming the dense vapour before mentioned. It is decomposed by sulphur, disengaging a little heat, and liberating violet vapours. Carbon has no action on it at any temperature. Solution of sulphurous acid decomposes it as well as iodic acid, precipitating the iodine as a brown powder. It is characterized by the manner in which potassium and phosphorus act on it: the instant they touch it they inflame; the potassium producing a white flame and dense vapours, but little or no liberation of iodine, and the phosphorus, with a noise as of ebullition, violent vapours appearing at the same time.

The odorous nature of this acid, its volatility, colour, and its power of inflaming phosphorus by mere contact, show that some of the principal characters of iodine are retained, and that it is oxygenated, therefore, in a minor degree, and deserves the name of iodous acid.

Its composition has not been experimentally ascertained. M. Sementini endeavoured to analyze it by putting 100 grains into the end of a long sealed tube, and then dropping a small piece of phosphorus in, iodine was disengaged, and condensed in the upper part of the tube, and this was found to amount to 45 grains; but this can furnish only very uncertain results.

Iodous acid dissolves iodine, becoming of a deep colour, more dense and tenacious, and having more strongly the odour o iodine. When heated, the iodine partially rises from the iodous acid, but they cannot be separated in this way.

M. Sementini believes also in an oxide of iodine, and has given the name to the black powder, which is produced by the action of sulphurous acid on iodous acid, and which still contains oxygen, but he mentions that this and some other points still require investigation.

The following are the properties of the iodic and iodous acids, by which a judgment may be formed of their specific difference. *Iodic acid* is solid, white, without odour, reddening blue colours, and then destroying them. Volatile at 456° Fahr. with decomposition; heated with charcoal or sulphur, it is decomposed with detonation. *Iodous acid* is liquid, yellow, odorous, reddening blue colours, but not destroying them; volatilizing at 112° Fahr. and even at common temperatures without decomposition; heated with sulphur it is decomposed without detonation, and inflames potassium and phosphorus by mere contact. *Bib. Univ.* xxv. 119.—(Journal of Science.)

5. *Inflammation of a Mixture of Oxygen and Hydrogen under Water.*

Every one is acquainted with the oxyhydrogen blowpipe. Mr. Skidmore, of New York, has observed that the luminous jet obtained with that instrument may be introduced under water, without being extinguished. The only precaution necessary is to introduce it slowly, that the flame may not be repelled into the receiver.

The flame viewed under water is globular. It burns wood, and heats metallic wires to redness. Mr. Skidmore thinks that his observation may be advantageously employed in maritime warfare.

6. *Advantageous Mode of using Alcohol in Vegetable Analysis.*

MM. H. Petroz and Robinet, in their examination of the fruit of the lilas, treated the decoction of the grains with a large quantity of alcohol gradually added while in the state of a thick syrup, without reducing it to a further degree of dryness. By this mode the product of the decoction is at once divided into two portions, one soluble in alcohol, the other not. The decoction should not be evaporated to a very thick syrup, for in that case the precipitated matter retains some of the substances which should be taken up by the spirit. The alcohol must be of such a strength as not to be too much weakened by the water remaining in the syrup.—(Journal de Pharmacie.)

Mineralogy.

7. *Garnet.*

To the numerous analyses which have already been published of the individuals belonging to this important class of minerals, we have to add the following:—

1. Green trapezoidal garnet from the mine Gamla, in Sala. Sp. gr. 3·746.

Silica	36·62		18·42 oxygen
Alumina	7·53	}	10·31
Oxide of iron	22·18	}	
Lime	31·80	}	9·68
Magnesia	1·95	}	
	100·08		

2. The same, from the same locality, but obtained at a different period.

Silica	36·73		18·47 oxygen
Alumina	2·78	}	9·22
Oxide of iron	25·83	}	
Lime	21·79	}	9·93
Magnesia	12·44	}	
	99·57		

(Bredberg, Kongl. Vet. Acad. Handl. 1822, p. 83.)

3. Calcareous garnet, from Lindbo, in Westmannland. Colour, black and blackish brown. Crystal, the primitive rhomboid, sometimes with truncated lateral edges.

Silica	37·55		18·78 oxygen
Oxide of iron	31·35		9·61
Lime	26·74	}	8·65
Oxidule of manganese	4·78	}	
	100·42		

(Hisinger, ibid. 1821.)

These three analyses accord sufficiently with the formula which has been deduced as representative of the constitution of garnet; namely, an atom of a silicate of a base containing two atoms of oxygen + an atom of a silicate of a base containing three atoms of oxygen.

The mineralogical formula for the Sala garnet is

$$\left.\begin{matrix}C\\M\end{matrix}\right\}S + \left.\begin{matrix}A\\F\end{matrix}\right\}S$$

and for the Lindbo garnet,

$$\left.\begin{matrix}C\\mg\end{matrix}\right\}S + FS$$

It is greatly to be wished that this extensive genus were subjected to a more systematic examination than it has hitherto received, and as has already been done so successfully in the case of the pyroxenes and amphiboles. The accuracy of the preceding formula is indeed supported by strong arguments; but many, particularly of the older analyses, are contradictory of it, and the simplicity of the crystalline form of garnet renders peculiarly necessary a severe induction of facts, before it can be regarded as demonstrated that there are not at present confounded under this name several genera of minerals, which are essentially distinct from one another, even on the broad basis of the isomorphous theory.

8. *On Meionite.*

Our mineralogical readers are aware that within these few years analyses of this mineral have been successively published by Arfwedson, Gmelin, and Stromeyer. The results of the last two chemists were almost identical; but those of Arfwedson disagreed with both so materially, that it was obvious that either he or they must have been engaged with a different mineral from meionite. M. Arfwedson, in a letter to Schweigger, acknowledges his mistake, and states, that on repeating the analysis with an authentic specimen, he had obtained results which indicated exactly the same formula with those of Gmelin and Stromeyer. It is singular that the mineral which he originally analyzed, although scarcely differing in composition from leucite, was easily fusible before the blowpipe; whereas leucite is quite infusible.—(Jahrbuch der Chemie und Physik, ix. 347.)

9. *Erlanite, a new Mineral.*

Lustre, feebly shining to dull. Streak shining, with a fatty lustre. Colour, light greenish grey: streak, white. Massive. Sometimes compact, sometimes in small and fine granular distinct concretions. Fracture in some specimens foliated, in others splintery and even. Its structure is distinctly crystalline, but no specimen has yet been observed which admitted of regular cleavages. Hardness, between that of apatite and actynolite. Sp. gr. from 3·0 to 3·1. Before the blowpipe, it melts easily into a slightly coloured, transparent, compact pearl, and resembles gehlenite more closely than any other known mineral: from felspar it is distinguished by its greater sp. gr.; from Saussurite, by its inferior sp. gr. and hardness.

It was discovered in 1818 by Briethaupt in different parts of the Saxon Erzgebirge. It forms a part of the oldest gneiss formation, and is always mixed with more or less mica. Between Gros-Pöhle and Erla there exists a bed of it at least 100 fathoms in thickness. It has been used for upwards of 200 years as a

flux by the iron smelters, and until its examination by Briethaupt, it had been uniformly mistaken for limestone.

According to the analysis of Prof. C. G. Gmelin, it is composed of

Silica	53·160
Alumina	14·034
Lime	14·397
Soda	2·611
Magnesia	5·420
Oxide of iron	7·138
Oxide of manganese	0·639
Volatile matter	0·606
Loss	1·995
	100·000

(Schweigger and Meinecke's Jahrbuch der Chemie und Physik, vii. 76.)

10. *Native Compounds of the Oxides of Uranium and Sulphuric Acid.*

These new mineral bodies, alluded to by Berzelius, are thus described by Prof. John, their discoverer.

(1.) *Sulphate of Oxidule of Uranium.*—It always occurs crystallized, and most commonly in flattened prisms, from one to three lines in length, which are arranged in eccentric druses. Colour, beautiful emerald green, sometimes passing into apple green. Lustre considerable, glassy. Transparent; sometimes, also, opaque and dull. Brittle, and easily pounded. Soluble in water. The solution is precipitated chesnut brown by the triple prussiate of potash, yellowish green by alkalies, and in brown flocks by infusion of nutgalls. Nitrate of silver and metallic iron occasion no alteration; and a solution of barytes precipitates a white powder, insoluble in nitric acid. When ignited, it undergoes partial decomposition; for if, after this treatment, it be digested in water, a yellow coloured powder remains undissolved. It accompanies the following mineral, which had heretofore been erroneously regarded as an oxide of uranium.

(2.) *Subsulphate of Oxide of Uranium.*—It forms a thin, botryoidal, intense sulphur-yellow coloured coating over the surface of the minerals on which it is found. It is friable, and soils the fingers. Digested in water, a portion of it passes into solution. The residue dissolves in nitric acid; and both solutions possess the properties of a solution of sulphate of oxide of uranium.

Both minerals occur in Elias's mine, at the distance of about a league from Joachimsthal, in Bohemia.

The examination of these compounds, observes Dr. John,

affords a new proof of the superiority of the chemical over the external characters of minerals, for many other ores, as, for example, those which are usually styled nickel ochre, zinc ochre, black copper, most of the oxides of manganese, &c. are in a similar situation, not one of them being pure oxides.—(Schweigger and Meinecke's Jahrbuch der Chemie und Physik, ii. 245.)

11. *Notice of the Lenzinite from the Neighbourhood of Saint-Sever.*

This mineral differs extremely in its appearance; it is most commonly met with in amorphous masses, from the size of the fist to that of the head: it is much lighter than limestone, and covered externally with a yellowish brown coating of oxide of iron. Internally, it is of a fine dead white, opaque, homogeneous, compact; of a fine grain, and soft and soapy to the touch; it is susceptible of being polished by rubbing with the finger. It adheres strongly to the tongue, and may be cut with the knife; but is sufficiently brittle to break under the hammer into sharp angular pieces. Its fracture is dull, and often conchoidal. When dipped in water, and then held near the ear, it crackles remarkably, but does not split, like the *argillaceous lenzinite* of John. It gives no effervescence with acids, becomes hardened by fire, but not sufficiently so, to scratch glass.

According to Pelletier's analysis, it consists of

Silica	50
Alumina	22
Water	26
Loss	2
	100

In its external appearance, it has much resemblance to the compact carbonate of magnesia.

M. Leon Dufour describes three varieties of this mineral.—(Annales des Sciences Naturelles.)

12. *American Localities of some Minerals.*

Mr. Shepard has found, what he considers as *yenite*, at Cumberland (R. I.); at Chesterfield, fine specimens of green feldspar and siliceous oxide of manganese, containing occasionally small octohedral crystals of magnetic iron. These two were found near the spot where the sappare is obtained.

Beautiful green feldspar has been recently found at Beverley (Massachusets), by the Rev. Elias Cornelius; small portions of purple fluor are disseminated in its fissures.

Mr. Jacob Porter gives the following localities:—

Calcareous tufa, exhibiting impressions of vegetables, has been found at Semphronius, New York.

Limpid quartz, in good crystals at Saratoga Springs, and at Sand Lake, New York; and the following chiefly in Massachusetts.

Blue quartz, ferruginous quartz, fetid quartz, chalcedony, hornstone, grey and red jasper, prismatic mica, black tourmaline in milky quartz, silver-grey scapolite, black hornblende, graphite, and oxide of manganese.

Mr. Steuben Taylor found feldspar in large crystals, actynolite in potstone, graphic granite, and ferruginous quartz, at Berkhampstead; black mica and prismatic mica, at Hartford; radiated quartz, at Canton; kyanite, at Chatham; garnets in mica slate, at Middle Haddam; epidote and gneiss, at Plainfield; galena, at White Creek (N. Y.); smoky quartz, at Killingly; ferruginous sand in great abundance at Black Island; and green talc, at Smithfield, R. I.

To this list we shall add some other localities given by Dr. Emmons.

Siliceo-calcareous oxide of titanium (sphene) in oblique four-sided prisms, of a light brown colour, associated with augite and actynolite, and also in sienite, at Chester.

Phosphate of lime, in an aggregate of grey epidote, zoisite, hornblende, and quartz, same place.

Manganese, chabasie, stilbite, carbonate of lime, in various forms, at Cummington; beryl, at Norwich and Chester, in an aggregate of carbonate of lime, chlorite, and feldspar; prismatic and tabular mica, indicolite? garnets and staurotide, of every variety, in mica slate, Norwich. A curious variety of cyanite occurs here, in a very fine soft mica slate (resembling potstone), often in hemitrope crystals, colour, greyish blue; also ferruginous oxide of titanium (nigrine?) in granite, and oxide of titanium (titanite?), in flat plates, in mica slate.

Augite abounds here in amorphous masses.

Sahlite and coccolite occur in mica slate; magnetic oxide of iron is abundant in mica slate, serpentine, &c.; rhomb spar is found in dolomite at Middlefield, and a large mass or rock of the rhomb spar of the same place, contains fibrous tremolite.

Agate, at Chester, a large mass found near the village, in the sand. It consists of yellow jasper and chalcedony, and weighed upwards of 180 lbs. after several large fragments had been broken off. Another large mass of the same materials, partly agatized, almost twice the size of the preceding, was found near the same place.—(American Journal of Science.)

13. *Vesuvian Minerals.* (Extract of a Letter from Signor Monticelli.)

The torrents of water which followed the eruption of Vesuvius in 1822 exposed several minerals, some of them new, to view. They consist of lapis lazuli, found in the midst of the red sand,

thrown out on the 24th of October; different varieties of quartz (flint and menilite, and specimens passing from those substances to a lava of amphigene and pyroxene); phosphate of lime in hexahedral prisms; melilite in cubes, similar to those from Capo di Bove (the last two found in a current (of lava ?) on the declivities of Mont Somma, above Pollena); gehlenite, similar to that from Fassa; specular iron, octohedral oxidulated iron; antimonial iron and glass of antimony combined with a little osmium.—(Bulletin des Sciences Naturelles.)

14. *On the Contractions of Crystals by Heat.*

M. Mitscherlich has observed that the mutual inclination of the faces of Iceland spar vary in a sensible manner by the effect of heat, and that between 0° and 100° (32° and 212° Fahr.) the change from the dihedral angles to the extremities of the axis of the rhomboid is $8\frac{1}{2}'$. It results from this, that if we suppose the dilatation of the crystal perpendicular to its axis to be nothing, its cubic dilatation should still exceed that of glass by nearly one-half; but on measuring the cubic dilatation of Iceland spar with M. Dulong, M. Mitscherlich found, on the contrary, that it is less; which leads to the singular consequence, that while heat dilates the crystal in a direction parallel to its axis, it must cause it to contract perpendicularly. M. Mitscherlich has ascertained this to be the fact, by measuring with a spherometer, at different temperatures, the thickness of a plate of Iceland spar, cut in a direction parallel to its axis. It is very probable that sulphate of lime may present an analogous phenomenon, but the reverse of the preceding; that is, that elevation of temperature may produce a sensible contraction in the direction of its axis. *A. F.*—(Annales de Chimie.)

15. *On the Inclination of the Line dividing the Optical Axes of certain Crystals.*

It is known that the *optical axes* of crystals, improperly called *crystals with two axes*, do not coincide with the axes of crystallization; and it has been hitherto regarded as a general law, that the right lines which divide the angle contained between the optical axes into two equal parts must be equally inclined on the corresponding faces of the crystal. M. Mitscherlich has found that these lines, *symmetrical* with respect to the double refraction, are not always so with respect to the faces of the crystal, and that in some salts, such as the sulphate of magnesia, they are more inclined to one side than the other, without any want of symmetry in the crystalline form, leading one to presuppose any such deviation. *A. F.*—(Annales de Chimie.)

Geology.

16. *On the Accuracy of the Inference that certain Formations have been deposited from Fresh Water, deduced from the Organic Remains found in them.*

Dr. Mac Culloch, in a very interesting paper, *on the Possibility of changing the Residence of certain Fishes*, which appeared in the 34th number of the Journal of Science, having shown, that several species of salmon spend a large portion of their time in fresh water; that the smelt has been familiarised entirely to fresh water, in which it has been kept for three years by Colonel Meynell, in Yorkshire, propagating and thriving abundantly; that the pike is found in the Caspian Sea; and that many other fishes live and thrive indifferently either in fresh or salt water, concludes with the following judicious observations:—

"There is a subsidiary question arising out of these speculations respecting the convertibility of the habits of marine animals, highly interesting to geology, and on which it will not be out of place to say a few words, although unfortunately not much solid information can be procured respecting it. This relates to the power which many, perhaps all the vermes inhabiting shells, possess of residing indifferently in salt or fresh water. It is well known to geologists that with respect to many, if not all of those deposits supposed to have been formed, like that of Paris and of England, under fresh water, the question mainly rests on this, namely, whether the shells now supposed, from certain analogies and peculiarities of structure, to have been inhabitants of fresh water lakes, may not have equally existed in salt lakes, or even in the sea. Some experiments towards the elucidation of this subject have been instituted in France, but I need not detail them, as they must be fresh in the recollection of all the readers of this journal. It has also been recently ascertained by M. Freminville, that in the gulf of Livonia, the shell fish which usually inhabit the sea, and those which belong to fresh waters, are found living together in the same places. While these confirm the general presumption which forms the basis of this communication, their general probability is also strengthened by that analogy. A few facts of common occurrence on our own shores seem to add additional weight to the opinion that the testaceous fishes in general are not rigidly limited to one kind of water, but are capable of living in both.

"On our sea coasts, the common muscle is invariably larger and fatter at the entrance of fresh water streams into the sea, particularly if these bring down mud, and in these places the water is scarcely salt; yet they live also and propagate in abundance on shores which receive no fresh water. The oyster is

transported from the sea to brackish water, where it also not only lives, but improves in condition.

"In the same manner the common cockle inhabits indifferently the muddy sand-banks near the æstuaries of rivers, which are always soaked with fresh water, and those sandy or half muddy shores where no such water is found. These are by no means the whole of the instances which might be enumerated in support of an opinion, of which the determination is so important in the present state of geological science; but as this subject is too important to pass lightly over, and as the bounds of this communication are already exceeded, I shall leave it to those who may have the means and the inclination to examine it in greater detail. I will only add, that the same considerations will lead to similar doubts, where it has been attempted by geologists to determine the nature of strata, as to their marine or fresh water origin, by that of the remains of fishes found in them."—(Journal of Science.)

Miscellaneous.

17. *Fulminating Powders employed as Priming for Fowling Pieces.*

The fulminating substances which have hitherto been employed for this purpose are four in number. 1. Fulminating silver; 2. Fulminating mercury; 3. A mixture of 100 parts of chlorate of potash, 12 of sulphur, and 10 of charcoal; 4. A mixture of 100 parts of chlorate of potash, 42 of nitre, 36 of sulphur, and 14 of lycopodium. A variety of experiments on their comparative advantages have been recently made in the chemical laboratory in the University of Halle, by Lieut. P. W. Schmidt. The following appear to be the most useful conclusions at which he arrived.

Fulminating mercury answers the purpose completely, but he does not agree with Mr. Wright in considering it preferable to fulminating silver. On this point, however, we feel disposed to differ with Mr. S. By his own admission, it never fails to inflame the gunpowder, and as it is not nearly so explosive as fulminating silver, the risk attending its employment must be proportionally less. The first mentioned mixture of chlorate of potash is much preferable to either of the metallic fulminating powders. It is not so liable to accidental explosion; it leaves behind it less acid matter, and does not corrode the iron so rapidly; and, contrary to what takes place with fulminating mercury, its explosion is not followed by a deposition of moisture. The facility and certainty of the explosion is the same in both.

The second mixture of chlorate of potash is not nearly so efficacious as the first; although this is chiefly a consequence of the ordinary construction of the touch-hole. The method of

filling the copper caps, recommended by Mr. Wright, is not only tedious but dangerous; a much preferable one is to mix up the explosive compound into a thick liquid, with any adhesive solution or tincture, and by means of a hair pencil to introduce a large drop of this mixture into the bottom of each cap.

The Germans, we suppose by way of practical refutation to the hackneyed reproach of national dulness, have anticipated their neighbours in making a novel application of fulminating powder. A good many years ago, an attempt to murder was made by sending by post to the obnoxious person a box containing a quantity of the powder, and within which several of the common fulminating papers were cemented in such a manner, that they must have exploded on removing the lid. Fortunately, however, although the explosion took place, it did not communicate to the rest of the powder. The criminal was detected, and, after a judicial trial, was suitably punished.—(Schweigger's Neues Journal für Chemie und Physik, xi. 66.)

18. *On a new Method of destroying Calculi.*

Dr. Civiale introduces a straight silver sound into the bladder through the urethra. This first sound incloses a second, also of silver, and straight and hollow like the first, and furnished at its extremity with three spring branches, which lie close together whilst ensheathed in the principal sound, but when pushed out they separate and form a sort of cage, in which, with some dexterity on the part of the operator, the stone is caught, when the cage is immediately closed by his drawing the sound towards him.

The second sound, in its turn, incloses a long steel cylinder, terminating, at the end next the bladder, and between the jaws of the cage, in a little circular saw, or file, of such form as may be most applicable, according to circumstances. When the stone is well fixed, the steel cylinder is pressed against it, and by means of a small pully fixed at its exterior extremity, a watchmaker's turn-bench, on which it is mounted, and a drill bow, it is worked like a drill for piercing a hole in a piece of metal. A dull sound is immediately heard proceeding from the abrasion or splintering of the stone. A spontaneous discharge of urine, or an injection of tepid water into the bladder, usually terminates the operation, and occasions the expulsion through the urethra, dilated by the introduction of the large sound, of the fragments of the calculus.

This process was first tried before the Commissioners of the Academy on the 13th of last January, on an individual of the name of Gentil, thirty-two years old. On the 3d of February, when the operation was repeated for the third time, the calculus was entirely removed. The pain was almost nothing, and during the progress of his cure, M. Gentil always went on foot to the house of M. Civiale.

19. *White's Floating Breakwater.*

Among the practical and useful inventions of the present day, the floating breakwater of Mr. White, for which he has received a patent, promises to hold a respectable place.

This contrivance consists of a series of square frames of timber, connected by mooring chains, or cables, attached to anchors or blocks; they are disposed so as to inclose either a rectilineal or a curvilineal space for the reception of ships, which may ride there, protected from the breaking of the sea or surf.

These frames consist of logs of Quebec yellow pine, from thirty to fifty feet long, and from eighteen to twenty inches thick. The logs are bolted together so as to form a square frame, consisting of two parallel frames. The separate frames are connected by ropes or chain cables, secured to anchors or moving blocks. The height of these frames may be increased by logs, or pieces of timber, on the tops of the frames, not exceeding five tiers in a vertical position, for the purpose of breaking the waves more completely in places where the water is violently agitated.

The advantages of this breakwater have been actually experienced at Deal, and certified by some respectable persons of that place.

The inventor recommends it particularly for fishing coasts, where the surge often prevents boats from putting off and landing; and also for bathing places, where it will always produce smooth water, and protect the machines. A drawing and more minute description of this invention will be found in Newton's London Journal of Arts, &c. vol. vii. p. 232.—(Edin. Jour. of Science.)

20. *Marobia.*

The "Marobia" is an extraordinary phenomenon, most probably deriving its name from Mare Ubbriaco, or Drunken Sea, as its movement is apparently very inconsistent. It occurs principally on the southern coast of Sicily, and is generally found to happen in calm water, but is considered as the certain precursor of a gale. The marobia is felt with the greatest violence at Mazzara, perhaps from the contour of the coast. Its approach is announced by a stillness in the atmosphere, and a lurid sky; when suddenly the water rises nearly two feet above its usual level, and rushes into the creeks with amazing rapidity; but in a few minutes recedes again with equal velocity, disturbing the mud, tearing up the sea weed, and occasioning noisome effluvia: during its continuance the fish float quite helpless on its turbid surface, and are easily taken. These rapid changes (as capricious in their nature as those of the Euripus) generally continue from thirty minutes to upwards of two hours; and are succeeded by a breeze from the southward, which quickly increases to heavy gusts. *Smyth's Memoir of Sicily.*—(Edin. Phil. Jour.)

Article XIII.

NEW SCIENTIFIC BOOKS.

PREPARING FOR PUBLICATION.

Dr. Thomson has in the press a new work, entitled An Attempt to establish the First Principles of Chemistry by Experiment.

Dr. Prout is preparing a greatly enlarged edition of his Inquiry into the Nature and Treatment of Calculus.

Outlines of a System of Medico-Chirurgical Education, containing Illustrations of the Application of Anatomy, Physiology, and other Sciences to the principal practical points on Medicine and Surgery; with Plates. By T. Turner, Member of the Royal College of Surgeons of London, Lecturer on Anatomy, &c.

Mr. Maund, of Bromsgrove, well known as a practical disciple of Flora, will commence on the 1st of Jan. 1825, a monthly publication, to be entitled, The Botanic Garden, or Magazine of Hardy Flowers; intended as a popular Manual for Botanists and Florists.

A Manual of Pharmacy. By T. W. Brande, Esq. 8vo.

A Dictionary of the Apparatus and Instruments employed in the various Operations of Philosophical and Experimental Chemistry, is about to be published by a Practical Chemist.

JUST PUBLISHED.

An Essay on Instinct and on its Physical and Moral Relations. By Thomas Hancock, MD. 8vo. 12*s.*

A Treatise on the Use of the Natural and Fictitious Waters of Carlsbad, Emms, Marienbad, &c. By Dr. F. Kreysig, of Dresden. Part II. Royal 8vo. 5*s.* 6*d.*

The Natural History of the Bible. By Thaddeus Mason Harris, DD. of Dorchester, Massachussetts. 8vo. 10*s.* 6*d.*

Letter on the projected Rail-road between Liverpool and Manchester. By Joseph Sandars. 1*s.*

Article XIV.

NEW PATENTS.

F. H. W. Needham, David-street, Middlesex, for his improved method of casting steel.—Oct. 7.

W. Foreman, Bath, Somersetshire, commander in the Royal Navy, for improvements in the construction of steam-engines.—Oct. 7.

F. Benecke, Deptford, verdigris manufacturer, and D. T. Shears, and J. H. Shears, Fleet-market, coppersmiths, for improvements in the making, preparing, or producing of spelter or zinc.—Oct. 7.

P. Alegre, Commercial-road, Middlesex, engineer, for his economical method of generating steam applicable to steam-engines and other useful purposes.—Oct. 7.

H. Jeffreys, Park-street, Bristol, merchant, for his improved flue or chimney for furnaces and other purposes.—Oct. 7.

Article XV.

METEOROLOGICAL TABLE.

1824.	Wind.	Barometer. Max.	Barometer. Min.	Thermometer. Max.	Thermometer. Min.	Evap.	Rain.
9th Mon.							
Sept. 1	S E	30·12	30·11	85	56	—	
2	E	30·12	30·09	86	54	—	
3	N E	30·09	30·01	80	64	—	10
4	W	30·01	29·89	75	52	—	
5	W	29·89	29·65	72	55	—	
6	S E	29·66	29·65	72	56	·77	14
7	S W	29·65	29·54	72	53	—	1·05
8	S	29·79	29·54	66	48	—	14
9	W	29·92	29·79	66	48	—	34
10	N W	29·92	29·81	68	54	—	54
11	S W	29·81	29·76	70	57	—	32
12	S W	30·18	29·76	68	48	—	04
13	S W	30·18	30·15	70	52	—	
14	S	30·16	30·15	72	63	—	03
15	S W	30·35	30·16	73	53	—	
16	N	30·35	30·25	72	55	·75	
17	E	30·25	30·17	72	59	—	
18	N E	30·17	30·05	75	58	—	
19	W	30·05	29·98	67	55	—	24
20	N	29·98	29·97	63	45	—	12
21	W	30·15	29·98	60	46	—	02
22	N W	30·15	30·05	65	53	—	12
23	N E	30·13	30·04	65	52	—	
24	N	30·13	30·12	66	52	—	—
25	N W	30·13	30·12	60	39	—	—
26	N W	30·12	29·72	50	37	—	17
27	N E	29·94	29·67	48	34	—	19
28	N W	30·04	29·94	52	27	—	
29	S E	30·04	29·76	61	43	—	
30	S	29·76	29·32	70	52	·80	21
		30·35	29·32	86	27	2·32	3·77

The observations in each line of the table apply to a period of twenty-four hours, beginning at 9 A. M. on the day indicated in the first column. A dash denotes that the result is included in the next following observation.

REMARKS.

Ninth Month.—1, 2. Fine. 3. Cloudy: a few drops of rain at one, p. m.: a shower in the night. 4. Cloudy and fine. 5. Fine. 6. Morning showery: afternoon fine. 7. Showery: very wet night, with thunder and lightning. 8—11. Showery. 12. Showery morning: afternoon fine. 13—18. Fine. 19. Cloudy. 20. Showery morning: fine afternoon. 21, 22. Cloudy. 23. Fine. 24, 25. Showery. 26. Fine. 27. Showery: a clap of thunder at half-past three, p. m. followed immediately by a heavy shower of hail of the size of peas: rain afterwards with thunder: the quantity of hail was sufficient to cover the ground in places. 28—30. Fine.

RESULTS.

Winds: N, 3; NE, 4; E, 2; SE, 3; S, 3; SW, 5; W, 5; NW, 5.

Barometer: Mean height

For the month	29·974 inches.
For the lunar period, ending the 16th	30·038
For 14 days, ending the 8th (moon south)	29·986
For 13 days, ending the 21st (moon north)	30·055

Thermometer: Mean height

For the month	59·350°
For the lunar period	63·300
For 31 days, the sun in Virgo	62·870
Evaporation	2·32 in.
Rain	3·77

Laboratory, Stratford, Tenth Month, 22, 1824. R. HOWARD.

ANNALS

OF

PHILOSOPHY.

DECEMBER, 1824.

Article I.

Biographical Sketch of the late Rev. E. D. Clarke, LL.D., Professor of Mineralogy in the University of Cambridge, &c.

Edward Daniel Clarke was born June 5, 1769, at Willingdon, in the county of Sussex, and was descended from a line of ancestors, whose learning and abilities reflected, for a long series of years, the highest credit upon the literature of their country. The celebrated Dr. William Wotton was his great-grandfather. His grandfather, 'mild William Clarke,' was one of the most accomplished scholars of his age; and his father, the Rev. Edward Clarke, was distinguished in the same honourable career. He is represented to have been from his infancy a most amusing and attractive child; and particularly to have exhibited in the narrow sphere of his father's parish, the same talent for playful conversation and narrative, which ever afterwards distinguished him in the various and extensive circles through which he moved. He showed, when very young, a decided inclination to those objects of science which were the favourite studies of his later years. Having received the rudiments of his education at Uckfield, a small town within his father's parish of Buxted, under Mr. Gerison, who had been his grandfather's curate, and his father's preceptor, he was removed, when somewhat more than ten years old, to the grammar-school of Tunbridge, at that time conducted by Dr. Vicesimus Knox. But his progress here was not very satisfactory: his attention appears to have been engrossed by various attractive subjects, some of a scientific nature, which were altogether inimical to his progress in classical literature. In the year 1786, when only sixteen years of age, he obtained, through the kindness of Dr. Beadon, then Master of Jesus College, and now the venerable Bishop of Bath and Wells, the situation of Chapel Clerk in that Society.

The three years which Edward Clarke spent in College, before he took his Bachelor's Degree, present no incidents of life, or

points of character, sufficiently important to occupy a place in this brief memoir; nor has there been found a single academical composition written by him at this time, in any department of learning, either in prose or verse, which would be considered worthy of his subsequent fame. Indeed, it is not the least extraordinary circumstance in his history, that this critical period, which generally lays the foundation of other men's fortunes, and exercises the greatest influence upon the conduct of their future lives, was by him suffered to pass, not only without academical honours or distinctions of any kind, but apparently without fixing any character whatever upon his literary views; and evidently without even those moderate advantages which a common mind might have derived from it. The loss itself, however, is much more easy to account for, than the singular vigour of mind, with which he afterwards redeemed it. Mathematical studies formed the principal path to College honours and emoluments, but for these, unhappily, Edward Clarke had no taste, and therefore made little progress in them; and with respect to classics, in which, as intimated above, he came up with a moderate knowledge, there was nothing at that time, either in the constitution or the practice of his College, calculated to encourage a taste already formed for them, much less to create one where nothing of the kind was felt before. Under these circumstances, with a strong literary passion, and at sea, as it were, without a pilot, upon the great waters of mental speculation, it was natural for him to form his own plans, and to steer his own course. Though he made little progress in the appropriate studies of the place, his literary ardour was not directed to unworthy objects, nor conducted upon a narrow scale. His active mind ranged lightly over a wide and interesting field of literature: history, ancient and modern; medals, antiquities, with all the variety of polite learning which is comprehended under the name of the Belles Lettres, shared by turns his attention and his time. But English Poetry was the natural element in which his youthful and ardent imagination delighted to expatiate. To these pursuits may be added Natural History in some of its branches, particularly Mineralogy; but, as he had few books, and no assistance in these subjects, it was not probable that he could make much progress in them.

About the end of the year 1789, he took his degree of Bachelor of Arts, and within a few months afterwards, through Dr. Beadon's recommendation, he became the tutor of the Hon. Henry Tufton, with whom he made the tour of Great Britain in the summer of 1791. This was undoubtedly a most important epoch in Mr. Clarke's life; it was the first opportunity he had of gratifying a passion which was always uppermost in his mind, but which he had hitherto been unable to indulge; and it necessarily threw in his way many opportunities of acquiring

information in those branches of natural history, for which he had early shown a decided taste, and to which he afterwards owed so much of his celebrity. It was likewise the cause of his first appearance before the public in the character of an author; he kept a journal of his tour, and at the request of some of his young friends, upon his return, was induced to publish it. The work is now exceedingly scarce, the greater part of the copies having been destroyed or lost within a short period after its publication. Indeed, Mr. Clarke himself soon learnt to have a lower opinion of its merits than others perhaps, more considerate, would be disposed to entertain, when the age and circumstances of the author are taken into the account.

In October, 1791, Mr. Tufton's brother being about to join Lord Thanet in Paris, Mr. Clarke and his pupil seized the opportunity of passing over with him to Calais, and thus he who afterwards traversed so large a portion of the globe, first set his foot on foreign ground; a circumstance which imparted to his ardent mind the most delightful sensations. In the spring of the year 1792, his engagement with Mr. Tufton terminated; and Lord Berwick, who had been of the same year with him in College, and was now of age, proposed that Mr. Clarke should accompany him, in the capacity of a friend, to Italy. This proposal was soon agreed to, and about the middle of July, they set out on their intended tour. As it was necessary to avoid the French territory, which was then agitated throughout by the paroxysm of its ferocious revolution, they took the route of the Low Countries to Cologne, and then ascending the Rhine to Schaffhausen, passed from thence through Switzerland, by the way of Lucerne and St. Gothard, to Turin.

To a mind like that possessed by the subject of this memoir, panting for foreign climes, and glowing with all the warmth of poetic imagery, it was no small achievement to have thus passed the barrier of the Alps, and to tread in the paths which had been hallowed in his eyes by the footsteps of Addison and Gray. But this was only a part of his enjoyment while on this tour. The country which he had entered, abounded in scenes and objects calculated, above all others, to awaken every pleasing association connected with his early studies, and to gratify his prevailing taste. The precious remains of antiquity dispersed throughout Italy, the fine specimens of modern art, the living wonders of nature, of which even the descriptions he had read, or the faint resemblances he had seen, had been sufficient to kindle his enthusiasm, were now placed before his eyes, and submitted to his contemplation and inquiry; nor were the springs and resources of his own mind unequal to the excitement which was thus powerfully acting upon them. At no period, even of his subsequent life, does he seem to have exerted himself with more spirit, or with better effect. He made large and valuable addi-

tions to his stock of historical knowledge, both ancient and modern. He applied himself so effectually to the French and Italian languages, as to be able in a short time to converse fluently, and to obtain all the advantages of acquirement and information in both; and, what was less to be expected, by dint of constant and persevering references to those classical authors, whose writings have contributed, either directly or indirectly, to illustrate the scenery or the antiquities of Italy, he made greater advances in Greek and Latin than he had done before, during the whole period of his education. He studied with great attention the history and progress of the arts, and, more particularly, of the different schools of Painting in Italy; reading carefully the best authors, conversing frequently with the most intelligent natives, and then, with all the advantage of his own good taste and discernment, comparing the results of his inquiries with those of his own actual observation.

Nor was his attention less powerfully attracted towards those rich treasures of Natural History, which the peculiar resources of the country, or the industry of collectors daily presented to him. Vesuvius, with all its various phænomena and productions, was his particular study and delight. He was the historian and the guide of the mountain, to every intelligent and distinguished Englishman, who came to Naples during his stay; and connecting, as he did, a considerable degree of science and philosophy, with all the accurate local knowledge, and more than the spirit and adroitness of the most experienced of the native guides, his assistance was as eagerly sought after as it was highly appreciated by his countrymen. He made a large collection of vases and medals, many of which have since found their way into different cabinets of Europe; and besides numerous valuable additions which he made to his own specimens of minerals, he formed several complete collections of Italian marbles and volcanic products for his friends. With his own hands he constructed models of the most remarkable temples and other interesting objects of art or nature in Italy; and one particularly of Vesuvius, upon a great scale, of the materials of the mountain, with such accuracy of outline and justness of proportion, that Sir William Hamilton pronounced it to be the best ever produced of the kind, either by foreigner or native; it is now at Lord Berwick's seat at Attingham, in Shropshire. These things he did, and much more, within an interrupted space of two years, during which, as it appears from his journal, so many of his hours were placed by his own good nature at the disposal of his countrymen in their literary or philosophical inquiries, so many others were dedicated as a matter of duty to Lord Berwick and his concerns, and so many more were devoted to the pleasures of society, and to those active amusements which our countrymen usually assemble round them whenever they take up their

abode together, and for which the fine climate of Italy is so well adapted, that it must be a matter of surprise to learn, that he was able to do so much for himself. Nor will this surprise be lessened, when it is known, that besides his journal, he left behind him a great number of manuscripts connected with this tour, including some maps of his own construction.

In the winter of 1793, Lord Berwick having formed a plan of a voyage to Egypt and the Holy Land, and submitted the preparations for it to Mr. Clarke, his whole time and thoughts were, for several weeks, almost exclusively occupied in this project. In the month of November he left Naples for England, on some particular business for his lordship, which he had undertaken to execute, in order to facilitate their journey to the east, and was landed at Dover on the 30th. Having arranged the business in question, he was on the point of setting off on his return, when he received a letter from Lord Berwick, intimating the sudden postponement, or, in other words, the abandonment of the voyage.

"It would require a very intimate knowledge of the sanguine character of Mr. Clarke," his biographer, Mr. Otter, remarks, "and of his passionate desire for seeing Egypt and Greece, to appreciate adequately the effect of this communication on his mind; but it may suffice to say, that the disappointment was felt by him more bitterly than any which he had ever before experienced in his life; that for many years it was even breaking out in his letters and conversation, and that it could never be said to be entirely overcome till under other auspices, and at a maturer age, he had been permitted to drink freely of that cup which was at this time unexpectedly dashed from his lips."

Mr. C. set off on his return for the Continent on the 20th of January, 1794, and arrived at Naples early in March. His residence there with Lord Berwick, however, continued only for three weeks more; and travelling by Rome, Aosta, and St. Remy, through Switzerland to Manheim, and thence by Mayence to Cologne and the Low Countries, they landed at Harwich on the 8th of June.

In the autumn of the year 1794, at the recommendation of the Bishop of St. Asaph, Dr. Bagot, Mr. Clarke was requested to undertake the care of Mr. Mostyn (now Sir Thomas Mostyn), at that time a youth of about seventeen years of age. He accordingly went to reside with Sir Roger Mostyn's family, at Mostyn, in Wales, but, for some unexplained reason, the connexion ended in little more than a year. In the course of the general election of 1796, he was one of a large party assembled at Lord Berwick's seat in Shropshire, at that time a scene of prodigious interest and agitation, in consequence of the contest for the borough of Shrewsbury, between the Hills of Attingham, and the distinguished family of the same name, and of a kindred race,

at Hawkstone. This contest was the means of exhibiting Mr. Clarke's talents in controversy,—a field in which they had never been exercised before, and in which, happily for himself, they scarcely ever appeared afterwards. The occasion of it was this: a long and laboured pamphlet, called "*Hard Measure*," had just issued from the opposite party, written as was supposed by Sir Richard Hill himself, and containing many sharp and cutting reflections upon the Attingham family and cause, with some strong documents in support of them. To this it was necessary to reply without delay; and for the sake of greater dispatch, several literary friends of Lord Berwick, who were in the house, undertook to divide the task amongst them, each taking the part which he thought himself most competent to answer; but as it was afterwards evident that this scattered fire would be much more effectual, if skilfully brought together, and directed by a single hand, Mr. Clarke was fixed upon for this purpose, and to him was confided the delicate and difficult operation of selecting, shaping, and combining, from the materials so prepared; with permission, of course, of which he availed himself largely, to add whatever arguments of his own he might think likely to increase the general effect. Accordingly, he set himself to work with his usual spirit, and having scarcely slept while it was in hand, he produced, in a very short time, matter enough for a quarto pamphlet, of a hundred closely printed pages, which, having been carefully revised by the lawyers, was rapidly hurried through the press, and immediately published, under the happy title of "*Measure for Measure.*" This work answered completely the object it had in view: it produced a great sensation at the time, was a source of no inconsiderable triumph to the party whose cause it advocated, and, as it is believed, received no reply.

Mr. Clarke accompanied Lord Berwick to Brighton, in the autumn of the same year, and there commenced a periodical work, entitled, "*Le Rêveur, or the Waking Visions of an Absent Man.*" It proceeded no further than the twenty-ninth number, the first of which was dated Brighton, Sept. 6, 1796, and the last, London, March 6, 1797. With the exception of a single number, or at most two numbers, furnished by his valued friend the Rev. George Stracey, and two short poems, one by Miss Seward, the other by Dr. Busby, afterwards Dean of Rochester, it was entirely the production of his own pen. The principal materials upon which he depended, were the substance of the information he had gathered, and of the observations he had made in the different situations in which he had lived, whether at home or abroad, since the publication of his tour; but as these were of a nature soon to be exhausted, and as the contributions of his friends came in but slowly, we cannot wonder that it was brought to a conclusion within the compass of a few

months. Before it had extended so far, also, the author was engaged in an occupation which required the greatest part of his time, and all the attention he could command. The work is now no longer to be found: the separate numbers, which obtained no great circulation, have, it is thought, perished long ago, with few if any exceptions: and the volume in which they were afterwards reprinted collectively, was stifled by an accident in its birth ;—some cause of delay had intervened to prevent its publication, and the whole impression was found in the bookseller's warehouse, so injured by the damp that not a single copy could be made up for sale. By this time, however, Mr. C.'s fears respecting the success of his work had begun to predominate over his hopes ; and he afterwards confessed to a friend, that he was never more delighted in his life, than when this accident so completely put an end to both.

The next occurrence to which the history of Mr. Clarke's life conducts us, is his connexion with the family of the late Lord Uxbridge ; a connexion formed, it is uncertain under what auspices, or upon what terms, but eventually not less honourable to Mr. Clarke, than satisfactory to many members of that family, to whom, in the course of his engagement, he became intimately known. The first object of his care was the youngest son of the family, the Honourable Brownlow Paget; a boy of tender age, and of a constitution so very delicate, as to render it advisable that his education should be commenced as well as continued at home. In this view an engagement of some standing with Mr. C. was contemplated by the family ; and rooms having been expressly prepared for their permanent residence together, at Beau-Desert, the seat of Lord Uxbridge, in Staffordshire ; he joined his pupil at that place, in the autumn of 1796. In the following spring, however, Mr. Paget's health, which had hitherto been considered as only delicate, began visibly to decline, and before that season was far advanced, his disorder arrived at a fatal termination. Mr. Clarke's connexion with Lord Uxbridge, though interrupted, was not broken, by this unhappy blow. The family had too much regard for his past services, and were too sensible of his many excellent qualities and talents,—which had been displayed in a manner endearing to them when his services as a tutor had ceased to be of any use to his pupil,—when the exercise of his kindness as a friend was alone available, —not to desire to profit by them, so long as any occasion should remain ; and, on the other hand, Mr. Clarke was too deeply impressed with the value of their friendship, not to acquiesce readily in any similar arrangement which could be proposed. Happily, in a few weeks, an opportunity offered itself for gratifying the wishes of both. The next youngest son of the family, the Honourable Berkeley Paget (now one of the Lords of the Treasury), had finished his education at school, and had

been admitted at Oxford: and, it having been thought advisable that the summer before his residence in College should be spent in travel, Mr. Clarke was desired to undertake the tour of Scotland with him, and the plan was carried into execution without delay.

This journey, which was begun in the summer, and concluded in the autumn of 1797, furnishes considerable extracts for Mr. Otter's work. "Mr. Clarke's journal," he observes, "is very full and particular, and evidently drawn up with a view to the publication of it by himself. At several subsequent periods of his life, preparations were made by him for this purpose; and so late as the year 1820, an advertisement was drawn up, announcing it to the public, and a part of the manuscript was actually transcribed for the press. Beyond this, however, no farther step was ever taken towards the completion of the work, and in the pressure of other labours, which occupied him to the last moment of his life, abundant reason might be found for the delay; but in truth, there was another obstacle, which requires some explanation, because, whatever share it may have had either in delaying or preventing the publication of the journal by himself, it certainly led to a restriction, which must diminish the interest of the extracts, when selected by another. This obstacle was the unsettled nature of his opinions respecting certain facts, connected with geology, accidentally a prominent feature in the tour. In the course of his Italian travels, his attention was frequently and specially directed to the two great theories, which at that time divided, and have since continued to divide, the judgment of philosophers, in every part of Europe. To this subject allusions are often made in his Italian journal, as well as in his letters after his return; and the interest thus excited in his mind, although afterward apparently suspended, was revived with much greater force, when the journey to Scotland was proposed to him. It was not that he attached an undue importance to any opinions he might form in that early stage of his knowledge: but he was eager to engage in the inquiries to which the controversy had given rise; and having had frequent occasion during his residence in Naples, to notice the observations of Scotch gentlemen, relative to the resemblance which they affirmed to exist between the minerals of the Western Islands and the productions of Vesuvius, he was willing to believe, that by a stricter scrutiny of this tract than it had hitherto received, he might be able to ascertain more correctly the nature and extent of this resemblance, with its proper bearing upon the controversy; and he was the more sanguine in this hope, because after the particular attention which he had paid for nearly two years, to the operations of subterraneous fire, both in a state of activity in Vesuvius, and in the traces of its influence among scenes no longer subject to its immediate

agency, he thought himself so far competent to recognize them in any other country, if they were to be found. This is the substance of his own acount, and one natural consequence of his pre-occupation was, that his attention was more alive upon the journey to geological facts, than to any other; and that a larger portion of his time and labour was bestowed upon this question, than it would naturally have claimed, in a tour not undertaken expressly with a view to it. Had this, however, been the only objection, the reader might not have lost much; for whatever value might be attached to his inferences at that time, his researches are often curious and minute, and his reasoning always ingenious and amusing; but it unfortunately happened, that the leaning of his judgment in the course of his tour, seems to have been in a different direction from that which it afterwards took, when, in a maturer state of his own knowledge, the learned and accurate labours of Dr. Maculloch had been submitted to him. Hence the difficulty, which applied to himself, and hence the restriction enjoined upon his friends; in conformity to which they feel themselves compelled to withhold, not only those parts of his journal in which his arguments are directly stated, but even all the more general remarks from which his mode of reasoning might be inferred."

The limits to which we are necessarily confined preclude us from enlarging on this northern tour, which occupied Mr. Clarke and his companion three months, from June 22 to Sept. 26, 1797. The narrative of it in the work is carried on from the isle of Ailsa to the conclusion of the journey, from Mr. C.'s journal; written in an extremely animated and pleasing style, and describing the scenery of the Western Islands and of the country through which they passed, in an interesting and vivid manner.

At Easter, 1798, having been elected a Fellow of Jesus College before his departure for Scotland, Mr. Clarke prepared to take up his residence there. In the mean time a new engagement was proposed to him, which led eventually to important consequences; being the cause of his undertaking, and the means of his completing the extended tour in Europe, Asia, and Africa, from which the fame he subsequently acquired was principally derived. The object of the proposal was a young man of his own neighbourhood, in Sussex, Mr. Cripps; who having lately succeeded to a considerable estate in that county, was desirous of placing himself under the guidance and instruction of Mr. Clarke for three years, in the meritorious hope of supplying the defects of an indifferent education, by those means, which though late were still within his power. In the pursuit of this advantage, the place was of secondary importance to him, and he was easily induced, at Mr. Clarke's recom-

mendation, to admit himself a Fellow-commoner of Jesus College, and to accompany his tutor to Cambridge; with an understanding, which was equally agreeable to both, that after a certain time spent in preparatory study, they should undertake some journey to the Continent together. The pecuniary part of the proposal was very liberal; the plan was entered upon without delay; and during the next twelvemonth, Mr. Clarke resided constantly with his pupil at Jesus College.

Mr. Clarke and the early and intimate friend who has become his biographer, the Rev. W. Otter, had long entertained a scheme of going abroad together, and during this year of his residence in Cambridge, he often urged upon Mr. O. the immediate execution of this plan. As no part of the Continent was then open to English travellers, but the north of Europe, it was at length determined, after various plans had been proposed and rejected, that they should visit Norway and Sweden, with as much of Russia besides, as could be comprehended within the extended limits of a long summer vacation. Mr. Cripps was of course of this party from the beginning, and with it was afterwards associated a gentleman since highly distinguished in the literary world, Professor Malthus.

The party set out from Cambridge on the 20th of May, 1799, and the journey which was at first intended to occupy only six or seven months, was continued by Mr. Clarke and his pupil for more than three years and a half, having been concluded in the latter end of November, 1802. Their companions, adhering to the original arrangement, left them near Lake Wener, in Sweden, and thence proceeded to the south of Norway.

Dr. Clarke's "Travels" having been so extensively perused, and the general course of the tour being in consequence so well known, we shall dismiss the subject with the following brief statement of its extent, extracted from a letter to Mr. Otter, dated Constantinople, Feb. 15, 1802:—"In examining the extent of our travels by Mercator's chart, I found they comprehend no less than 45 degrees of east longitude, from the meridian of Greenwich to that of Cape St. Mary, in the isle of Madagascar; and 38° 30′ 30″ of North latitude. We have visited three of the four quarters; Europe, Asia, and Africa; and certainly in Asia, the tract we passed over comprehends no small field of inquiry. The globe offers very little variety of climate, to which we have not been exposed, and in the examination of its productions, we have the satisfaction to hope, that you will neither reproach us with idleness nor neglect." The travellers left Constantinople in the suite of the Ottoman Ambassador to France, and passing through Bulgaria, Wallachia, Transylvania, and Hungary, arrived at Vienna in May, whence they set out for Paris in the beginning of July, and returned to England in October, 1802; Mr. C.

commencing his permanent residence at the University towards the end of the following month.

For some time Mr. Clarke took no College office, nor was such an employment essential to, or even compatible with his views, for Mr. Cripps still continued with him as his pupil, and the engagements arising out of his travels were quite sufficient to occupy all the time he had to spare: amongst these his first care was to collect and examine the cases and packages, containing their acquisitions in the various departments of antiquity, art, and science, which had been awaiting their arrival at the different custom-houses of the country. Mr. C. had sent to England more than seventy cases of his own before he left Constantinople, whilst his companion had upwards of eighty, obtained under his advice and influence; and considering the remoteness of the places from which they had most of them been dispatched, and the variety of conveyances to which they had been entrusted, so little had been sustained by them, either of loss or of injury, as to be matter of just congratulation to the collectors.

Of all these treasures, the first place in Mr. Clarke's mind was given to the Eleusinian statue of Ceres; and this, not only on account of the high distinction to which the statue was destined in the University, but for the rank he assigned to it, amongst the monuments of the purest age of Grecian sculpture, and the many classical associations connected with its history. By the liberality of Government, it was allowed to be taken out of the custom-house duty free; and when at last a place had been assigned to it by the University authorities in conjunction with the donors, and the proper preparations had been made for its reception, it was securely placed upon its pedestal, with all due form and honours, in the most conspicuous part of the vestibule of the Public Library, on the 1st of July, 1803; and the names of Dr. Clarke and Mr. Cripps were, by the desire of the University, inscribed upon the base. The public appearance of the statue was quickly followed by a tract from Mr. Clarke's pen, which naturally grew out of the transaction, and was indeed important to the illustration of it. In this work, which is entitled "Testimonies of different Authors, respecting the Colossal Statue of Ceres," the monument in question is clearly proved to be the very individual bust, described as lying at Eleusis, by Wheler and Spon, Pococke, Chandler, and others, and considered generally as the representation of the Goddess. In the winter of this year a grace was passed unanimously in the senate of the University, for conferring the degree of LL.D. upon Mr. Clarke, and that of MA. upon Mr. Cripps; and to mark with more distinction the sense of the University, in conferring these honours, a third grace was subsequently carried, to defray the whole expense of Dr. Clarke's degree from the University chest.

"The next object connected with his travels to which he directed the public attention, was the celebrated Sarcophagus, now in the British Museum, captured from the French at Alexandria. It is well known how instrumental Dr. Clarke had been in discovering this noble monument of Egyptian art, when it had been clandestinely embarked for France, on board a hospital ship, in the port of Alexandria, and in rescuing it from the hands of General Menou, and the French Institute, who clung to it with a degree of obstinacy almost incredible: and it was very natural that the interest he had taken in it in Egypt, should revive with its arrival in England; especially as the origin of the monument soon became the subject of much speculation and perplexity amongst the learned, and Dr. Clarke conceived himself to be possessed of evidence calculated to throw light upon it. Under this impression he drew up, in 1805, a Dissertation on the Sarcophagus in the British Museum, brought from Alexandria. It was inscribed to Lord Hutchinson, under whose authority he had acted in Alexandria, and the main object of it was to vindicate the pretensions of the monument to the title of the tomb of Alexander. To this hypothesis he had been first led by the name it bore (the tomb of Iscander), amongst the most ancient race of the neighbouring inhabitants, coupled with the extreme veneration felt for it as such by the Turks and other persons of every description in the city of which this hero was the founder; and having been afterward partially confirmed in his opinion by the reports he found in the works of early travellers, as well as by the conversation of learned men on the continent, and at last more decidedly by an accurate examination of such classical authors, as had treated of the subject of Alexander's death and burial, he collected his proofs and arguments in a manuscript, which, after being handed about among his friends, in 1804, was by their advice published in the following year, under the title already mentioned. The work had been placed in the hands of Lord Hutchinson, with a view to its being printed by the Antiquarian Society, but was afterward withdrawn at the suggestion of his friends, who thought it would appear more expeditiously, as well as advantageously, from the University press, the managers of which undertook to print it.

"It was ornamented with an accurate coloured engraving of the tomb, from a drawing by Alexander, and accompanied with several appendices, in one of which was inserted a learned and ingenious illustration by Dr. Parr, of a Greek inscription found among the ruins of Tithorea by the author; and being the first book in which the name of Edward Clarke had appeared in the title page (all his former publications having been anonymous), it was otherwise got up with great care, and at no inconsiderable cost. But this over-nursing was in one respect injurious to it.

The subject, though excellent for a pamphlet, was neither popular nor comprehensive enough for the expensive form in which it was thus obliged to appear (the price was 18*s*.), and the introduction of such topics as the ruins of Sais and Tithorea, however interesting in themselves, was so far injudicious, that it injured the unity of the piece, and added to the expense without furnishing any ground for the argument: thus, notwithstanding the advantages under which it came out, the work was by no means lucrative, either to himself or his publisher, Mr. Mawman, in whose hands a large number of copies remained for many years. To the author, however, it was productive of essential advantage in many ways. By the few who read it, it was, for the most part, well received and highly estimated: amongst whom are mentioned by himself, Porson, Parr, Dr. Zouch, Lord Aberdeen, Dr. Henley (Principal of Hertford College), Dr. Knox (his early tutor), Mr. Tyrwhit, Mr. Matthias, &c.; all of whom gave their countenance and approbation, and some their assistance or advice in the work. It was the means, also, of making him more favourably and more intimately known to other men of learning and genius, whose friendship he never lost. Above all, it gave him confidence in his own powers, and enabled him to stand upon much higher ground, when soon afterwards he had to treat with the booksellers for his travels. Nor can it be denied, that his position was maintained with great ingenuity: by many learned persons, the proofs were considered conclusive, as their letters show; others, more reserved, readily expressed their surprise that such a mass of evidence existed; and all were disposed to allow, that a vague and obscure tradition had been elevated in his hands to the rank of a learned and probable conjecture.

The extraordinary activity of Dr. Clarke's mind enabled him, in the very midst of a controversy to which this publication gave rise (Easter, 1805), to compose and send to press "a treatise on Mineralogy, principally intended for students, of which the following notice is given in a letter to Dr. Henley:— 'I have already sent another work to the press, very different in its nature, which will be mere play to me this Easter vacation. It is "an easy and simple method of arranging the substances of the mineral kingdom," by which I hope to make mineralogists, as fast as Bolton makes buttons. The introduction only is addressed to persons rather above the class of students, and is intended to develope the theory of elementary principles, the cause and origin of the fluid matter of heat, the formation of atmosphere, &c. &c. It is a portable volume, small and pleasant for travellers.' The work was never published, and its existence is scarcely known to any of his friends, but one or two copies were found amongst his papers, and a slight view of it is sufficient to show that it must have cost him considerable time

and labour, at the moment his hands appeared to be full of other things."

A matrimonial connexion which Dr. Clarke had now for some time contemplated, rendering it necessary for him to enter into professional life, he determined to take holy orders, and was ordained by his old friend, the Bishop of Bath and Wells, in Dec. 1805, and immediately instituted to the vicarage of Harlton, belonging to Jesus College. On the 25th of March, 1806, he was married to the lady of his choice, Miss Angelica Rush, the fifth daughter of Sir William Rush, of Wimbledon; and to this union, from which, and for reasons apparently cogent, unhappy consequences had been anticipated by his friends, his future life was indebted for its greatest happiness, and even its prosperity.

The course of Dr. Clarke's life now turns from this happy union to a department of his labours, which had long been uppermost in his own thoughts, and next to his 'Travels,' obtained for him his highest distinctions, as a literary man:—viz. his Lectures on Mineralogy. During the whole course of his travels, that science, and the objects connected with it, obtained everywhere the greatest share of his attention, and had been cultivated by him with the greatest success; to which several circumstances had contributed. Low at that time as was this branch of natural history in our Universities, it had risen under a variety of encouragement and patronage—the result of policy as well as of taste—to a high degree of importance in every public establishment for education on the Continent; and, as Mr. Clarke brought letters of recommendation to the most eminent professors wherever he went (an advantage which his own spirit always contributed to improve), he was in all places cheerfully admitted to a participation of all the local discoveries or improvements, and supplied with specimens of all such minerals as they respectively produced. But this was not all; the course of his travels often led him to remote districts, particularly in the eastern and southern parts of Russia, not accessible to the ordinary mineralogist; and as he spared neither pains nor money in his researches, besides a very ample store of minerals more or less known, he brought to England several rare and valuable specimens, which were for some time almost peculiar to his collection: and it may be affirmed generally, that of all the fruits of his travels, his acquisitions in this department were infinitely the most precious in his eyes. To bring forward, therefore, this collection before the public eye, and with more advantage than his own limited apartments would permit,—to communicate to others the lights which he himself had obtained, and to disseminate throughout the University a portion of that flame which burned within himself, were, from the first, subjects infinitely more pressing in his mind, than the hope of reputation or advantage from any other quarter; and as the only obvious means of

embracing at once these objects was the delivery of lectures under the patronage of the University, it was to the attainment of this, that his best efforts, from a very early period after his return, were uniformly directed. But the task was not an easy one. The subject was little known and less studied, and by no means popular in the University; nor was there any room suited to the purpose, but what was either pre-occupied or appropriated; and besides, there was an apprehension of the Lectures interfering with the Woodwardian Professorship, at that time occupied by a gentleman for whom Dr. Clarke had justly a very great respect. By degrees, however, all these difficulties gave way. Every facility was afforded by the University to the plan; Dr. Martin, the Botanical Professor, gave up his room in the Botanic Garden, which his age and infirmities prevented him from using himself; and the Woodwardian Professor, whose proper department was Geology, so far from considering these Lectures as an interference with himself, kindly concurred in every measure which was required for their establishment. In short, as soon as he could enter upon it, Dr. Clarke had the happiness to find, that the field was open to him without either opposition or ill-will, and the fiat of the Vice-Chancellor followed almost as a matter of course. Having, therefore, finished his preparations, which were both expensive and laborious; and having published a new synopsis of the mineral kingdom, and an extensive syllabus, he at last announced a day for the opening of his Lectures, the 17th of March, 1807. They were crowned with complete success; and in the course of the following year, his reputation as a Mineralogist, in the University, was so far established, as to encourage his friends in the hope of obtaining for him the establishment of a new Professorship in his name. This measure met at first with some opposition, and having been prematurely pressed, had in the first instance failed; but in the latter end of 1808, the second year of his Lectures, the sense of the University having been previously tried, a grace to that effect was brought up to the senate by the Proctor, the Rev. G. D'Oyly (now Dr. D'Oyly, Rector of Lambeth, &c.) and carried almost unanimously.

Thus were his most sanguine wishes crowned with success, and thus were his spirit and perseverance rewarded with one of the rarest and the highest honours which the University could bestow. Not long afterwards the rectory of Yeldham, in Essex, was presented to him by Sir W. Rush.

The next important concern in which he engaged was the disposal of the manuscripts he had collected in his travels. These, after having been examined by Prof. Porson, and other eminent scholars, were purchased in 1809 by the Curators of the Bodleian Library, at Oxford, for 1000*l.* His Greek coins, the

fruits of the same travels, he disposed of to the late Mr. Payne Knight, in the course of the next year, 1810. On both these occasions Dr. Clarke displayed great liberality during the negociation, with much anxiety for the ulterior use and destination of the collections. Early in the year last mentioned, the first volume of his 'Travels' appeared, the second in 1812, the third in 1814, the fourth in 1816, the fifth in 1819: of the sixth only twelve chapters were finished at his death; the rest were added by his friend the Rev. Robert Walpole, to whom the public are indebted for many interesting and valuable notes in the former volumes.

The year 1817 opened with a most flattering testimony of the esteem in which he was held in the University, by his election to the office of Sub-Librarian, vacant by the death of Mr. Davies, and the promotion of Mr. Kerrich to that of Principal Librarian. His attention during this year was principally occupied by his experiments with the 'Gas Blowpipe,' most of which he described in the *Annals*.* In the same year he contributed two papers to the Society of Antiquaries, and one to the Geological Society; all which have been noticed in the *Annals*: (vol. ix. p. 395, and N. S. vol. vii. p. 73). In 1819 he collected his experiments with the 'Gas Blowpipe' into a small octavo volume, which was published under that title, with engravings of the instrument, the safety apparatus, &c. This year also produced his Dissertation on the Lituus, read before the Antiquarian Society in 1820, and published in the Archæologia for 1821.

Dr. C. was one of the most zealous founders of the Philosophical Society of Cambridge, and drew up, for the first meeting, an address explanatory of the design and objects of the Institution. This address is given in the *Annals* for March, 1821. He afterwards communicated three papers to the Society, which were printed in the first volume of its Transactions.

The history now advances towards the close of a life which had been long struggling with labours disproportioned to his strength, and was at last seen to sink under the workings of a mind too powerful and too active for the mortal part with which it was united. The progress of his disorder was slow, but the steps of it were strongly marked. At no time since his return from his last journey, could his health be considered as well established; and besides many other occasional derangements of his system, there was scarcely a single year in which the exertions and confinement attending his Lectures did not bring on some serious illness, frequently accompanying, but generally following them; and when these were over, instead of relaxation

* See vol. viii. p. 313, 357; vol. ix. p. 89, 162, 194, 326; vol. x. p. 373. Both series of the *Annals* contain papers on various other subjects by Dr. C.; and the last he ever wrote will be found in the number for March, 1822; N. S. vol. iii. p. 195.

and repose, he often found such long arrears of composition or correction for his Travels as required the strongest application to recover. It was not so much the number and variety of his employments that broke down his health, as the extreme and intense anxiety with which some of them, particularly the philosophical, were pursued by him; an anxiety which intruded upon his hours of rest, and rendered him insensible to those corporeal warnings, which usually guard other men against too continued or too intense an employment of their faculties. In the autumn of 1821, his wife, far advanced in pregnancy, and three of his younger children, sickened one by one with a typhus fever; and in a few days were all reduced by the violence of the disorder to a state of the most imminent danger. All happily recovered; but the fatigue and anxiety which Dr. Clarke underwent, aggravated the symptoms of his disorder, on its return in the winter of this year. This was succeeded by a sort of crisis, during which he was more thoroughly sensible of the perilous state of his health, than at any other period either before or after.

"A short and deceitful interval of ease followed, in which the intermitting of the disorder gave him reason to hope that he was slowly recovering; under which impression he entered once more, in the middle of the month, upon a course of chemical experiments, preparatory to his Lectures, which were to begin in March; and from the moment he had stepped within the circle of these fascinating operations, there was no longer either thought or power of retreating; for the usual excitement attending this preparation co-operating with the effects of the disorder, which ultimately terminated in an affection of the brain, brought on a course of unnatural efforts, infinitely exceeding all his former imprudencies, and partaking strongly of the delirium which quickly followed. 'I have left him in an evening,' says a friend, 'about this time, with a promise that he would go to bed, and on the following morning have found that he had been up a considerable part of the night, engaged in a series of unwholesome operations with sulphuretted hydrogen.' In this melancholy state of self-abandonment, deaf to the remonstrances of his friends, insensible of his own danger, almost incapable of self-control, and intent only upon the due performance of his approaching duties, he supported an ineffectual struggle with his disorder till the middle of February, when his strength entirely failing him, and being no longer able to stand up, he sunk reluctantly into his bed, and from thence dictated to his servant the course of operations he wished to pursue, and there received from him the results. Up to this time, however, the arrangements of his mind seem to have been vivid and distinct as far as philosophy was concerned, and its energies unabated. His last paper, in the *Annals of Philosophy* (N. S. vol. iii. p. 195), is dated the 6th of February, and contains a clear statement of

a complicated operation in chemistry, for obtaining cadmium from sheet zinc. On Tuesday the 12th, he wrote from his bed upon the same subject to the Rev. Mr. Lunn (who had frequently assisted him in his operations); and on Thursday the 20th, another letter to Dr. Wollaston, reporting his last operation. On Friday the 21st, Mr. Lunn saw him, when he was quite rational upon this subject, as far as he was permitted to speak, though sick and in bed. On Saturday he was carried to town for advice, by Sir William and Lady Rush, where he was attended by Sir Astley Cooper, Dr. Bailey, and Dr. Scudamore. But their efforts to save him were in vain; the rest of his life, about a fortnight, over which a veil will soon be drawn, was like a feverish dream after a day of strong excitement, when the same ideas chase each other through the mind in a perpetual round, and baffle every attempt to banish them. Nothing seemed to occupy his attention, but the syllabus of his Lectures, and the details of the operations, which he had just finished: nor could there exist to his friends a stronger proof that all control over his mind was gone, than the ascendancy of such thoughts, at a season when the devotion so natural to him, and of late so strikingly exhibited under circumstances far less trying, would, in a sounder state, have been the prime, if not the only mover of his soul. One lucid interval there was, in which, to judge from the subject and manner of his conversation, he had the command of his thoughts as well as a sense of his danger; for in the presence of Lieut. Chappel and Mr. Cripps, he pronounced a very pathetic eulogium upon Mrs. Clarke, and recommended her earnestly to the care of those about him; but when the current of his thoughts seemed running fast towards those pious contemplations in which they would naturally have rested, his mind suddenly relapsed into the power of its former occupants, from which it never more was free. At times indeed gleams of his former kindness and intelligence would mingle with the wildness of his delirium in a manner the most striking and affecting; and then even his incoherences, to use his own thought respecting another person, who had finished his race shortly before him, were as the wreck of some beautiful decayed structure, when all its goodly ornaments and stately pillars fall in promiscuous ruin. He died on Saturday, the 9th of March, and was buried in Jesus College Chapel, on the 18th of the same month.

"He left seven children; five sons and two daughters; the eldest not fifteen years of age at the time of his death.

"Few persons have left the world more honoured or more regretted. The tears of genius have been shed around his tomb, and every mark with which respect or kindness can honour departed merit is preparing to grace his memory.

"A monument, erected in Jesus College Chapel, near his grave,

at the expense of the Master and Fellows, will serve to stimulate the youth of that Society in the paths of enterprise and science: a bust, executed by Chantrey, at the cost of his literary friends, principally members of the Philosophical Society, at Cambridge, will perpetuate the honour of one of its most distinguished ornaments and founders: while his collection of minerals, fixed by the liberal suffrages of the University within its precincts, will remain an appropriate memorial of the respect paid by that body to their first mineralogical professor. But the best proof of the many excellent qualities of his heart, is the sincere and ready kindness shown towards his family since his death—kindness not less honourable to human nature, than to the individual for whose sake it has been exerted—derived not from the wealthy or the great, by whom it would be lightly felt, but from persons of his own rank and means, and involving sacrifices which nothing but friendship and affection could warrant.

A memoir, originally intended for publication in the *Annals*, having been the foundation of Mr. Otter's "Life and Remains of Edward Daniel Clarke, LL.D." the foregoing imperfect sketch of Dr. Clarke's life and labours has been selected from that work, almost entirely in the words of his biographer. A considerable proportion of the volume is occupied by Dr. Clarke's journal of his residence at Naples, and of his tour in Scotland; and by his letters to his friends while on his grand journey. These are extremely interesting; and Mr. Otter's narrative is perspicuous and well written; the arrangement of the work is altogether excellent: and we recommend it to the possessors of Dr. Clarke's 'Travels,' as an indispensable companion to those volumes. E. W. B.

Article II.

Astronomical Observations, 1824.
By Col. Beaufoy, FRS.
Bushey Heath, near Stanmore.

Latitude 51° 37′ 44·3″ North. Longitude West in time 1′ 20·93″.

Oct. 17.	Immersion of Jupiter's third satellite	16h	59′	23″	Mean Time at Bushey.
		17	00	44	Mean Time at Greenwich.
Oct. 29.	Immersion of Jupiter's first satellite	15	16	04	Mean Time at Bushey.
		15	17	25	Mean Time at Greenwich.
Nov. 2.	Immersion of Jupiter's second satellite	13	26	35	Mean Time at Bushey.
		13	27	56	Mean Time at Greenwich.
Nov. 5.	Immersion of Jupiter's first satellite	17	09	25	Mean Time at Bushey.
		17	10	46	Mean Time at Greenwich
Nov. 14.	Immersion of Jupiter's first satellite	13	30	48	Mean Time at Bushey.
		13	32	09	Mean Time at Greenwich.

Occultations by the Moon.

Nov. 2. Emersion of 19 Pisces..... 2h 10′ 13·8″ Siderial Time.

ARTICLE III.

On the Solution of $\psi^n x = x$. By John Herapath, Esq.

(*Concluded from* p. 329.)

§ 4. If in our primitive equation $\psi^n x = x$ we assume $x = u_z$ and $\psi^q x = u_{z+q}$, q being any quantity, and u a function to be determined, there results

$$u_{z+n} = \psi^n x = x = u_z$$

and by integration $u_z = 1^{\frac{z}{n}} \times A$,

A being the arbitrary constant. But because A is any quantity, and $1^{\frac{z}{n}}$ is a well known function of $\sin \frac{2k\lambda z}{n}$ and $\cos \frac{2k\lambda z}{n}$ it is also a function of sin or $\cos \frac{2k\lambda z}{n}$; and therefore

$$u_z = 1^{\frac{z}{n}} \times A = f\left(1^{\frac{z}{n}}\right) = \varphi \sin \frac{2k\lambda z}{n},$$

where f is an arbitrary function, and consequently φ. Again since

$$x = u_z = \varphi \sin \frac{2k\lambda z}{n}, \text{ and } \psi^v x = u_{z+v} = \varphi \sin \frac{2k\lambda(z+v)}{n}$$

we have

$$z + v = \frac{n}{2k\lambda z} \sin^{-1} \varphi^{-1} x + v$$

$$\text{and } \psi^v x = \varphi \sin \left\{\frac{2kv\lambda}{n} + \sin^{-1} \varphi^{-1} x\right\} \ldots\ldots (25)$$

a solution, with the advantage of being direct, and considerably more simple, is equally as general as either of the former. For instance, in the case of $n = 2$, if $v = 1$ and k any odd number,

$$\psi x = \varphi(-\varphi^{-1} x)$$

where it depends on the form of φ to have almost any algebraic form we please for ψ. Thus if we assume

$$\varphi^{-1} x = \frac{a + bx}{c + dx},$$

our form of ψ will come out the same as (23), excluding the arbitrary function. And if we consider that

$$\sin(a + b) = \sin a \,.\, \cos b + \sin b \,.\, \cos a$$

and

$$\cos \sin^{-1} \gamma = \sqrt{1 - \gamma^2}, \text{ we have}$$

$$\psi^v x = \varphi \left\{\sqrt{1 - \varphi^{-1} x^2} \,.\, \sin \frac{2kv\lambda}{n} + \varphi^{-1} x \,.\, \cos \frac{2kv\lambda}{n}\right\} \ldots (26)$$

which, from the facility of giving finite and often rational values to the transcendental parts, by choosing proper values for k, is

frequently preferable to either of the preceding formulæ in developing algebraic values of $\psi^v x$.

These very simple expressions at once give several of the properties of the functional root. Thus from the manner in which k is introduced, it may be any integral number 0, 1, 2, 3, to infinity; and therefore, generally, ψx will have k functional roots, k being the least integer that will make $\frac{k}{n}$ an integer. If, therefore, n be an integer, the number of roots will be n; if a fraction, they will be equal to the numerator of the fraction; and if an irrational number they will be infinite. And since k may be $= o$, it follows that whatever be the values of n and v, one value of $\psi^v x$ is x. It should however, in the solution of problems, be carefully considered, whether the conditions of the problem will admit the property $\psi^v x = x$ when $\psi^n x = x$. A very skilful mathematician in this branch of analysis, has fallen into error in the solution of one of his problems from not attending to this.

Again, because either expression (25) or (26) is symmetrical with respect to v and k, if k remain constant, and 0, 1, 2, ... be substituted for v, the results will be the same as if v remained constant, and 0, 1, 2, 3, ... be substituted for k. Consequently whatever be the value of n, the several values of ψx will be equal to $\psi^0 x$, ψx, $\psi^2 x$, $\psi^3 x$, ... This conclusion Mr. Babbage has arrived at by a very different process in his paper in the Philos. Transac. for 1817, when n is an integer; but such a limitation is evidently unnecessary.

Let us assume our expression (25) or (26) to be a function of k, v, and n. Then

$$\psi^v x = f\left(\frac{k\,v}{n}\right) \text{ and } \psi_1{}^v x = f\left(\frac{k\,v}{n_1}\right);$$

supposing that in the former instance $\psi^n x = x$, and in the latter $\psi_1{}^{n_1} x = x$. If therefore $n = p\,n_1$

$$\psi^p x = f\left(\frac{k\,p}{p\,n_1}\right) = f\left(\frac{k}{n_1}\right) = \psi_1 x$$

and $\psi^{2p} x = \psi_1{}^2 x$, $\psi^{3p} x = \psi_1{}^3 x$, $\psi^{4p} x = \psi_1{}^4 x$, ...

But if p be an integer, $\psi^p x$, $\psi^{2p} x$, ... are, by what we have just shown, functional roots of $\psi^n x = x$. Therefore and because $\psi_1 x$, $\psi_1{}^2 x$, ... are the functional roots of $\psi_1{}^{n_1} x = x$, it follows, that if the order of a periodic function be an integral multiple of the order of another periodic, the roots of the latter are roots of the former, whatever be the values of the orders of periodicity. Mr. Babbage has drawn, in the above-mentioned paper, the same inference for integral orders.

If in $\psi^n x = x$ we substitute ψ^{-n} for x we have

$$\psi^{-n} x = x;$$

the $\psi^{-1} x$, $\psi^{-2} x$, ... values of which are evidently equal to the functional roots of the former.

All the preceding properties are analogous to the properties of the roots of unity; but it would not be correct to conclude from hence that the parallel is strictly true in all cases. For instance, all the roots of unity, except one or two at most, are imaginary. In the case however of a periodic function, every root is real, if the order be real.

It is not one of the least remarkable features of our solutions that every order of the function positive, negative, &c. is given by the same formula, without the necessity of algebraic resolution;—a circumstance that has not been accomplished in any other solution with which I am acquainted. Several other consequences of high importance also readily flow from our last very simple solution, which I presume it would be in vain to expect from any other. Thus the extraction of any functional root of a periodic function αx of a given form and order; and the resolution of the equation $\psi^n x = x$, so that any order $\psi^r x$ of it may have one given form only, are questions easily resolved from the preceding solution, and obviously much too important in their consequences to need the notice of any particular instances, especially as I have treated on the subject in another place. I shall, therefore, merely indulge myself in the solution of a very common form, but more general functional equation of the kind than I have yet seen solved. Let the equation be

$$\psi x = \psi \alpha^r x; \ldots\ldots\ldots\ldots (27)$$

where $\alpha^n x = x$, and n, r, are any numbers. By our (25) we have

$$\alpha^r x = \beta \sin \left\{\frac{2 r k^1 \lambda}{n} + \sin^{-1} \beta^{-1} x\right\} \ldots\ldots (28)$$

β being the particular form of the arbitrary function which gives the solution in the rth order, the form $\alpha^r x$ and k^1 being any one invariable integer. Let us assume $x = u_z$ and $\alpha x = u_{z+1}$. Then $\alpha^r x = u_{z+1}$,

and

$$\psi x = \psi u_z = \phi \sin \frac{2 k z \lambda}{r} \ldots\ldots\ldots (29)$$

But the condition $\alpha^n x = x$ gives $u_{z+n} = u_z$, and therefore

$$x = u_z = \beta \sin \frac{2 k^1 z \lambda}{n} \ldots\ldots\ldots\ldots (30)$$

$$\text{as well as } \alpha^r x = u_{z+r} = \beta \sin \frac{2 k^1 z \lambda}{n}.$$

$$\text{and } 2 z \lambda = \frac{n}{k^1} \sin^{-1} \beta^{-1} x.$$

Substitute this value for $2 z \lambda$ in (29), and we have

$$\psi x = \phi \sin \left\{\frac{k n}{k^1 r} \sin^{-1} \beta^{-1} x\right\} \ldots\ldots\ldots (31)$$

the solution of (27) free from the symmetrical form, and therefore possessing many advantages over it in point of practical convenience; besides being complete for all values of r and n, which no other solutions, hitherto given of (27), are.

The solutions analogous to those usually given for a more limited form of (27), are

$$\psi x = \phi x + \phi \alpha^r x + \phi \alpha^{2r} x + \ldots . \phi \alpha^{q r - r} x \} \ldots \ldots \ldots (32)$$

and

$$\psi x = \chi \smile \{x, \alpha^r x, \alpha^{2r} x, \ldots . \alpha^{q r - r} x\}^* \ldots \ldots \ldots (33)$$

where q is the prime numerator of $\frac{n}{r}$, and $\phi, \chi \smile$ perfectly arbitrary functions, the latter being limited to symmetrical forms. These solutions are therefore confined to rational values of r and n, or at least of the quotient $\frac{n}{r}$; and cannot hence be called complete. Their multinomial forms too render them much inferior to (31), especially when they involve a function to be determined.

Our (31), it will be seen, demonstrates the practicability of applying Laplace's method to periodic functions, which has been much questioned. On this method I have some observations to make, which, for the present, brevity obliges me to withhold.

§ 5. From what we have said in deducing (25), it appears that $\sin \frac{2 k \lambda z}{n}$, $\cos \frac{2 k \lambda z}{n}$, and $1^{\frac{z}{n}}$, the expressions usually given for the integral of

$$u_{z+n} = u_z \ldots \ldots \ldots \ldots (34)$$

are only particular cases of the general integral $f(1^{\frac{z}{n}})$ or $\phi \sin \frac{2 k \lambda z}{n}$.

Even

$$\chi \left\{ \phi \sin \frac{2 k \lambda z}{n}, \phi_1 \cos \overset{\text{I}}{\frac{2 k \lambda z}{n}}, \phi_2 \tan \overset{\text{II}}{\frac{2 k \lambda z}{n}}, \phi_3 \operatorname{cotan} \overset{\text{III}}{\frac{2 k \lambda z}{n}}, \phi_4 \operatorname{vers} \overset{\text{IV}}{\frac{2 k \lambda z}{n}}, \phi_5 \operatorname{covers} \overset{\text{V}}{\frac{2 k \lambda z}{n}}, \phi_6 \sec \overset{\text{VI}}{\frac{2 k \lambda z}{n}}, \phi_7 \operatorname{cosec} \overset{\text{VII}}{\frac{2 k \lambda z}{n}} \right\} \ldots . (35)$$

which is also an integral of (34), and contains eight independent integers $k, k^1, \ldots .$ and nine arbitrary functions $\chi, \phi, \phi_1, \ldots .$ is virtually contained in $\phi \sin \frac{2 k \lambda z}{n}$. For though $k, k^1, \ldots .$ have no necessary dependence, yet during the time z changes to $z + n$, which time is simultaneous for each part of (35), they must be relatively constant. Therefore, during this time, cos

* In a letter to Mr. Babbage, dated Feb. 26, 1824, I committed, through haste, an oversight, in stating the last term of this solution, which I here take an opportunity of acknowledging.

$\frac{2k\lambda z}{n}$, $\tan\frac{2k''\lambda z}{n}$, ... are respectively functions of $\sin\frac{2k\lambda z}{n}$; and consequently whether we admit φ_1, φ_2, ... to be comprehended in φ or not the whole expression (35) sinks to an arbitrary function of $\sin\frac{2k\lambda z}{n}$, that is to $\varphi\sin\frac{2k\lambda z}{n}$. And the same coincidence might easily be shown to be true of any other apparently different integral, which from the nature of (34) must contain circular or equivalent periodic functions, so that (34) has really but one integral, involved, however, in an arbitrary function. This is likewise confirmed by a very simple, direct, and general method that has occurred to me of integrating equations of differences of, I believe, all orders and degrees; and which method is applicable to the direct numerical resolution of algebraic equations of all degrees as well as to other purposes, of which I may say more hereafter. Hence (25) or (26) does not admit of variety from variety of integral, but being obtained directly and without any limiting conditions from the integration, it must possess an equal degree of generality with the integral itself, that is, the integral being of the most general kind, the functional solution must be so too, or in other words complete. A complete solution, therefore, of $\psi^n x = x$ has only one arbitrary function.

A direct proof that our (25) is the complete solution may be given thus. Let $\varphi\,\alpha^v\,\varphi^{-1}\,x$ denote (25), or any other solution wherein α^v is the particular form of $\psi^v x$ when $\varphi x = x$. Suppose $f^v x$ is also any solution whatever that will fulfil the condition $f^n x = x$. Put $f^v x = \varphi\,\alpha^v\,\varphi^{-1}\,x$, and changing x into φx, we have $f^v\,\varphi x = \varphi\,\alpha^v\,x$, in which φ is the function to be determined. Now because f and α are periodics of the same order, this equation is always possible, whatever be the forms of f and α; and indeed I have in another place given general solutions of this very problem. It is, therefore, evident, that such a form can be given to the arbitrary function in (25), that this solution shall coincide with any other solution whatever. Consequently (25) comprehends every solution, and is, therefore, the complete solution.

This I believe is the first direct and legitimate demonstration that has been given of the completeness of a functional solution.

Hence it follows, that the arbitrary constants a_r, b_r, c_r, in (21) form a part of the arbitrary function in (25). This is further confirmed by the assumption with which we set out at the commencement of § 3, which, being arbitrary, of course gives an arbitrary form to the functional root. Arbitrary functions, therefore, of whatever kind or quantity they may be, substituted for these constants, merely clog the solution without at all contributing to its generality; since these functions, and the

consequences that can in any way flow from them, are naturally comprehended in the arbitrary function of the direct solution.

I cannot refrain here, while on the subject of periodic functions, from mentioning two curious cases of periodic solutions which are perfectly successful when the operations are merely indicated but not performed, and yet fail when developed; though the developed and undeveloped values are the same. The first I shall mention was noticed in elucidating some difficulties in this calculus to my promising friend and pupil Mr. Mervyn, Crawford, and the next occurred while considering the source of what Mr. Babbage denominates "a very difficult subject." It was mentioned to him in a letter dated March 22, 1824.

Let ψx be a periodic of the second order whose solution is evidently

$$F(x, \psi x) = 0,$$

where the form of F is to be determined. Substitute ψx for x, and it becomes

$$F\{\psi x, \psi^2 x\} = F\{\psi x, x\} = o = F\{x, \psi x\}$$

F is, therefore, symmetrical with respect to x and ψx. Consequently a solution is,

$$\psi x^n + x^n = 0,$$

in which n is unlimited, or

$$\psi x = \sqrt[n]{-x^n} = x \cdot \sqrt[n]{-1} \quad \ldots\ldots\ldots (36)$$

Now in all cases the first of these values $\sqrt[n]{-x^n}$ answers the conditions of the question; for $\psi^2 x = \sqrt{-(\sqrt[n]{-x^n})^n} = \sqrt[n]{x^n} = x$. But in the second value $x \cdot \sqrt[n]{-1}$, we have

$$\psi^2 x = x \cdot (-1)^{\frac{2}{n}},$$

which if n be of the form, $2p$ becomes $\psi^2 x = x \cdot \sqrt[p]{-1}$, an expression that cannot, with any integral value at least to p, be $= x$. It may be asked, in what this unexpected anomaly consists? The answer, I conceive, is obvious, if we seek it from the nature of the functions in question. Periodic functions are algebraic expressions whose property of periodicity depends not on the value but the form of the expression. If, therefore, the value be the same but the form be changed, the expression may no longer be periodic. Thus it happens in the above instance, the values of the two expressions are the same, but the forms different—the negative sign in the one case being a mere sign of subtraction, and in the other a factor.

This reasoning will appear still clearer in the following case. Suppose we have the equation

$$\psi x = c \psi . x^n \quad \ldots\ldots\ldots (37)$$

c being a constant. By changing x into $\frac{1}{x}$, it appears when $n = -1$, that c can only be $+1$ or -1. If, however, Laplace's method of differences be followed, we have for the solution of (37)

$$\psi x = A_1 c^{\frac{\log^2 A_0 - \log^2 x}{\log n}} \quad \ldots\ldots\ldots (38)$$

A_0, A_1 being the constants of integration. If now we change x into $\frac{1}{x}$, the solution becomes, putting p for the former exponent,

$$\psi \frac{1}{x} = A_1 c^{p-1}$$

Multiplying this by c, we have

$$c \psi \frac{1}{x} = A_1 c^p = \psi x,$$

which, therefore, satisfies the conditions of equality of the question without any apparent limitation to c, that is, without the necessary limitation the question requires. A part only, therefore, of the conditions of the question are satisfied; and this arises from the periodicity of the exponent being destroyed by the development of p. If we consider that by changing x into $\frac{1}{x}$ twice successively, p returns into itself, and suppose p by one such change to become q, we may easily find that

$$c^{p+q} = c^p \text{ or } c = \pm 1.$$

And in the same way if $n = \sqrt[r]{1}$, we should have $c = \sqrt[r]{1}$, provided the value of c be sought by the non-development of the function.

These illustrations will, I hope, obviate the difficulty noticed by Mr. Babbage in Phil. Trans. 1817, without having recourse to the ingenious but, I presume, controvertible idea of the function ψx, having simultaneously different values in different parts of the same equation. The same may be said of Mr. Herschel's views, p. 120, vol. ii. of the Examples.

As this is a subject of considerable importance in the theory of functions, I shall here briefly notice another more general instance of my observation; namely, that the same expression may be periodic or non-periodic according to its form. In our solution (25), k and φ are perfectly arbitrary. Take then $\Phi x = \sin^{-1} x$, and we have

$$\psi^v x = \sin^{-1} \sin \left\{ \frac{2 k v \lambda}{n} + \sin^{-1} \sin x \right\} = \frac{2 k v \lambda}{n} + x \ldots . (39)$$

the former value of which is periodic for every value of n, provided *sin* and *sin*$^{-1}$ act separately and distinctly, but the latter is not. I am aware it will be contended that the arithmetical values of $\psi^v x$ in (39) when differently developed, are not necessarily the same. This may be true in the present case, but it

will not hold in (36) or (38), and, therefore, does not militate against the general truth of my position, that the same expression may be periodic or non-periodic according to the form under which it is put.

JOHN HERAPATH.

ARTICLE IV.

Instructions respecting Paratonnerres, or Conductors of Lightning. Extracted from the Report of M. Gay-Lussac, in the name of a Commission appointed by the Royal Academy of Sciences of Paris.* (With a Plate.)

THE principal object of the report (which was drawn up at the request of the Minister of the Interior), is to direct workmen in the construction and mode of fixing conductors on buildings, &c. It is divided into two parts, one theoretical, the other practical.

Theoretical Part.

Principles respecting the Action of Lightning, or Electric Matter, and of Conductors.

Lightning is the sudden passage of electric matter through the air, with the evolution of great light, from clouds highly charged with that fluid; its velocity is immense, far surpassing that of a ball at the moment it leaves the cannon, and is known to be at the rate of about 1950 feet per second of time.

The electric matter penetrates bodies, and traverses their substance, but with very unequal velocities; through some, which are therefore called *conductors*, it passes with great rapidity; such are well burnt charcoal and water; vegetables, animals, and the earth, in consequence of the moisture they are impregnated with, and saline solutions; but, above all, metals afford the readiest passage to the electric fluid. A cylinder of iron, for instance, is a better conductor than an equal cylinder of water saturated with sea salt, in the ratio of at least 100000 : 1, and the latter conducts a thousand times better than pure water.

Non-conductors, or insulating bodies, oppose great resistance to the passage of electricity through their substance; such are glass, sulphur, the resins, and oils; the earth, stones, and bricks, when dry; air and aeriform fluids.

No bodies, however, are such perfect conductors of electricity as not to oppose some resistance; which, being repeated in every portion of the conductor, increases with its length, and may exceed that which would be offered by a worse but shorter

* From the Annales de Chimie.

conductor. Conductors of small diameter also conduct worse than those of larger.

The electric particles are mutually repulsive, and consequently tend to separate and disperse themselves through space. They have no affinity for bodies, they determine only to their surfaces, where they are retained solely by the pressure of the atmosphere, against which, they in their turn exert a pressure proportionate at every point to the square of their number. When the latter pressure exceeds the first, the electric matter escapes into the air in an invisible stream, or in the form of a luminous line, commonly called the electric spark.

The stratum of electric matter on the surface of a conductor is not of equal density at every point of its surface, except it be a sphere. On an ellipsoid the density is greater at the extremity of the great axis than on the equator, in the ratio of the great axis to the smaller; at the point of a cone it is infinite. In general, on a body of any form, the density of the electric matter, and consequently its pressure on the air, is greater on the sharpest or most curved parts, than on those that are flat or round.

The electric matter tends always to spread itself over conductors, and to assume a state of equilibrium in them, and becomes divided amongst them in proportion to their form, and principally to their extent of surface. Hence, if a body that is charged with the fluid be in communication with the immense surface of the earth, it will retain no sensible portion of it. All that is necessary, therefore, to deprive a conductor of its electricity, is to connect it with the moist ground.

Of several conductors of very unequal powers the electric fluid will always choose the most perfect; but if their differences be small, it will be divided amongst them in proportion to their capacity for receiving it.

A *Paratonnerre* * is a conductor which the electric matter of the lightning prefers to the surrounding bodies, in order to reach the ground, and expand itself through it: it commonly consists of a bar of iron elevated on the buildings it is intended to protect, and descends, without any divisions or breaks in its length, into water or a moist ground. An intimate connexion of the paratonnerre with the ground is necessary, in order that it may instantly transmit the lightning as it receives it, and thus defend the surrounding objects from its attacks. When lightning strikes the surface of the ground, for want of a good conductor it does not spread over it, but penetrates below it till it meets with a sufficient number of channels to carry it completely off.

* I adopt the French term, as we have none in our language to express in one word, a *conductor of lightning*, meaning thereby not merely the metallic rod, but the whole apparatus complete. At least we may as well use it as parasol, parachute, parabouc, &c.—*Tr.*

It sometimes leaves visible traces of its passage, even at a depth of more than 30 feet. When also a paratonnerre has any breaks in it, or is not in perfect communication with a moist soil, the lightning, having struck it, flies from it to some neighbouring body, or divides itself between the two, in order to pass more rapidly into the earth. Frequent instances of serious accidents have occurred from both these causes.

Before the flash ensues, the influence of the thunder cloud disturbs the natural electrical state of all the bodies below it at the surface of the earth, and brings them into a state contrary to its own; and thus every object becomes a centre of attraction towards which the lightning has a tendency to direct itself. In order that this effect may be suddenly produced, it is indispensable that the bodies influenced by the cloud be good conductors, and in perfect communication with a moist soil.

A paratonnerre perfectly connected with the ground, and terminating in a very sharp point instead of being rounded off, may become so intensely electrified by the influence of a thunder cloud, as to give off a continual stream of electric matter, which sometimes is visible in the dark, appearing as a luminous pencil at the extremity of the point, and must certainly tend, in part at least, to neutralise the electrical state of the thunder cloud. A rounded point may exert an equal, or even a greater attraction on the thunder cloud than a sharp one; but if the flow of electric matter from the point become very rapid, the lightning will strike sooner, and from a greater distance between the cloud and the paratonnerre, than if its extremity were rounded; at least electrical experiments lead to this conclusion.

Thus the most advantageous form that can be given to a paratonnerre appears evidently to be that of a very sharp cone. The higher a paratonnerre is elevated in the air, other circumstances being equal, the more its efficacy will be increased, as is clearly proved by the experiments with electrical kites, made by MM. de Romas and Charles.

It has not been accurately ascertained how far the sphere of action of a paratonnerre extends, but, in several instances, the more remote parts of large buildings on which they have been erected, have been struck by lightning at the distance of three or four times the length of the conductor from the rod. It is calculated by Charles, that a paratonnerre will effectually protect from lightning a circular space, whose radius is twice that of the height of the conductor; and they are now attached to buildings after that rule.

A current of electric matter whether luminous or not, is always accompanied by heat, the intensity of which depends on the velocity of the current. This heat is sufficient to make a metallic wire red hot, or to fuse or disperse it, if sufficiently thin; but it scarcely raises the temperature of a bar of metal, on

account of its large mass. It is by the heat of the electric current, as well as by that disengaged from the air, condensed by the passage of the lightning through it when not conveyed by a good conductor, that buildings struck by it are frequently set on fire.

No instance has yet occurred of an iron bar, of rather more than half an inch square, or of a cylinder of the same diameter, having been fused, or even heated red hot by lightning. A rod of this size would therefore be sufficient for a paratonnerre, but as its stem must rise from 15 to 30 feet above the building, it would not be of sufficient strength at the base to resist the action of the wind, unless it were made much thicker at that part.

An iron bar, about three-quarters of an inch square, is sufficient for the conductor of the paratonnerre. It might even be made still smaller, and consist merely of a metallic wire, provided it be connected at the surface of the ground with a bar of metal, about half an inch square, immersed in water or a moist soil. The wire indeed would pretty certainly be dispersed by the lightning, but it would direct it to the ground, and protect the surrounding objects from the stroke. However, it is always better to make the conductor so large as not to be destroyed by the stroke, and the only motive for substituting a wire for a stout bar is the saving in point of expence.

The noise of the thunder generally occasions much alarm, although the danger is then passed; it is over indeed on the appearance of the lightning, for any one struck by it neither sees the flash, nor hears the clap. The noise is never heard till after the flash, and its distance may be estimated at so many times 368 yards, as there are seconds between the appearance of the lightning and the sound of the thunder.

Lightning often strikes solitary trees, because, rising to a great height and burying their roots deep in the soil, they are true paratonnerres, and their shelter is often fatal to the individuals who seek it; for they do not convey the lightning with sufficient rapidity to the ground, and are worse conductors than men and animals. When the lightning reaches the foot of the tree, it divides itself amongst the conductors that it finds near it, or strikes some in preference to others, according to circumstances, and sometimes it has been known to kill every animal that had sought shelter under the tree; at others only a single one out of many has perished by the stroke.

A paratonnerre, on the contrary, well connected with the ground, presents a certain security against the lightning, which will never leave it to strike a person at its foot, though it would not be prudent to station one self too close to it, for fear of some accidental break in the conductor, or of its not being in perfect communication with the ground.

When lightning strikes a house, it usually falls on the chimneys, either from their being the most elevated parts, or because they are lined with soot, which is a better conductor than dry wood, stone or brick. The neighbourhood of the fire place is consequently the most insecure spot in a room during a thunder storm, where it is safer to station oneself in a corner opposite the windows, at a distance from every article of iron or other metal of any considerable size.

Persons are often struck by lightning without being killed, and others have been wholly saved from injury by silk dresses, which serve to insulate the body, and prevent the access of the electric matter.

Practical Part.

Details respecting the Construction of Paratonnerres.

A paratonnerre is a metallic bar, A B C D E F (Pl. XXXIV), fig. 1, rising above a building, and descending, without any breaks, to the ground, its lower end plunging into a well of water, or a wet soil. The vertical part B A is called the stem, and projects into the air above the roof, and the part of the bar B C D E F which descends from the foot of the stem to the soil, is called the conductor.

Of the Stem.

The stem B A is a square bar of iron, tapering from its base to the summit, in form of a pyramid. For a height of from 20 to 30 feet, which is the mean length of the stems placed on large buildings, the base is about $2\frac{1}{2}$ inches square.*

Iron being very liable to rust by the action of air and moisture, the point of the stem would soon become blunt, to prevent which a portion, A H, is cut off from the end, A B, fig. 2, about 20 inches in length, and replaced by a conical stem of brass or copper, gilt at its extremity, or terminated by a small platina needle, A G, two inches long.† The platina needle is soldered with silver solder to the copper stem; and to prevent its separating from it, which might sometimes happen, notwithstanding the solder, it is secured by a small collar of copper, as seen in fig. 3. The copper stem is united to the iron one by means of a gudgeon, which screws into each; the gudgeon is first fixed in the copper stem by two steady pins at right angles to each other, and is then screwed into the iron stem, and secured there also by a steady pin (see C, fig. 4). If the gilding of the point cannot easily be performed on the spot, nor the platina readily obtained, they may both be dispensed with without any incon-

* The best way of making a pyramidal bar is to weld together pieces of iron end to end, about two feet long each, and of successively decreasing diameters.

† Instead of the platina needle, one of standard silver may be substituted, composed of nine parts of silver and one of copper.

venience, and the plain conical copper stem only be employed. Copper does not rust to any considerable depth in the air, and even if the point become somewhat blunt, the paratonnerre will not thereby lose its efficacy.

A stem of the supposed dimensions being difficult to transport to a distance, it is cut into two parts A I, I B, fig. 2, at about one-third or two-fifths of its length from the base. The upper part, A D, fig. 4, fits exactly by a pyramidal tenon, D F, seven or eight inches long, into the lower part, E B, and is kept in its place by a pin. The stem should, however, always be made of a single piece whenever that can be done.*

Below the stem, three inches from the roof, is a cap, M N, fig. 4, soldered to the body of the stem, and intended to throw off the rain water which would flow down the stem, and prevent its running into the interior of the building, and rotting the rafters.†

Immediately above the cap, the stem is rounded for about two inches to receive a split collar, with a hinge O, and two ears, between which the extremity of the conductor of the paratonnerre is fixed by a bolt; the plan of this collar is seen at P below the stem. Instead of the collar, we may make a square stirrup, which embraces the stem closely; the vertical projection of this is seen at Q, fig. 5, and the plan at R, fig. 6, as well as the mode by which it is united to the conductor. Lastly, in order to save labour, we may solder a tenon, T, fig. 7, in the place of the collar; but care must be taken not to weaken the stem at this part, where it has to oppose most resistance, and the collar and stirrup are preferable. The stem of the paratonnerre is fixed on the roof of buildings, according to circumstances. If it is to be placed above a rafter B, figs. 7 and 8, the ridge must be pierced with a hole through which the foot of the stem passes, and is steadily fixed against the king-post by means of several bridles, as seen in the figure. This disposition is very solid, and should be preferred if local circumstances permit.

If the stem be to be fixed on the ridge at A, fig. 8, a square hole must be made through it of the same dimensions as the foot of the stem; and above and below we fix, by means of bolts, or two bolted stirrups, which embrace and draw the ridge together, two iron plates about three-quarters of an inch thick, each having a hole corresponding to that in the woodwork. The stem rests by a small collet on the upper plate, against which it is strongly pressed by a nut, which screws on the end of the stem against the lower plate; fig. 9 shows the plan of one of

* The hollow part, E G, fig. 4, which receives the pyramidal tenon, D F, is made thus:—A strong iron plate is rolled into a cylinder, and soldered at G to the bar B G; then by means of a mandrill of the same form as the tenon, and at successive heats, it is easy to unite its edges and to give it, inside and out, the pyramidal shape.

† To make the cap, an iron ring is soldered to the stem and drawn out all round on the anvil, inclining the edges so as to form a very flat truncated cone.

these plates. But if we can rest against the brace C D, fig. 8, we should solder two ears to the stem to embrace the upper and lateral faces of the ridge, and descend to the brace, on which they are fixed by means of the bolt, E.

Lastly, if the paratonnerre be to be fixed on a vaulted roof, it should be terminated by three or four feet, or spurs, which must be soldered into the stone, with lead, in the usual manner.

Of the Conductor of the Paratonnerre.

The conductor, as has been stated, is an iron bar about three-quarters of an inch square, B C D E F, fig. 1, or B′ C′ D′ E′ F′, reaching from the foot of the stem to the ground. It is firmly united to the stem, by being tightly jammed between the two ears of the collar O, fig. 4, by means of a bolt; or it may be terminated by a fork M, fig. 6, which embraces the tail, N, of the stirrup, and the two pieces bolted together.

As the conductor cannot be formed of a single piece, several bars are united end to end. The best method of doing this is seen at fig. 10. The conductor is supported parallel to the roof, at about six inches distance from it, by forked stanchions, which, in order to prevent their letting the rain into the building, are fashioned as follows:

Instead of terminating in a point, they have a foot, figs. 11 and 12, formed of a thin plate about 10 inches long, and $1\frac{1}{4}$ inch broad, at the extremity of which rises the stanchion, making either a right angle with the foot, fig. 11, or an angle equal to that which the roof forms with the zenith, fig. 12. The foot slips in between the slates, but for greater firmness a plate of lead is substituted for the lower slate, and the foot of the stanchion and the lead are nailed down to one of the rafters. The conductor is kept in the forks by pins rivetted through them, and the stanchions are placed at about 12 feet distance from each other.

The conductor, after turning over the cornice of the building, fig. 1, without touching it, is brought into the walls, down which it passes to the ground, and is fixed by means of cramps let into the stone. When it has reached to D or D′ in the ground, about two feet below the surface, it is bent at right angles to the walls in the line D E or D′ E′, and carried in that direction about 12 or 15 feet, when it turns down into a well, E F, or a hole, E′ F′, about 12 or 15 feet deep in the ground, if no water be met with, but a less depth is sufficient if there be water.

The iron buried in the ground in immediate contact with moist earth becomes covered with rust, which, by degrees, penetrates to its centre, and destroys it. This is prevented by placing the conductor in a trough filled with charcoal, D E, or

D′ E′, which is represented on a larger scale at fig. 13. The trough is constructed in the following manner:—

Having made a trench in the soil about two feet deep, a row of bricks is laid on their broad faces, and on them others on edge; a stratum of baker's ashes (*braise de boulanger*) is then strewed over the bottom bricks, about two inches thick, on which the conductor is laid, and the trough then filled up with more ashes, and closed by a row of bricks laid along the top. Tiles, stone or wood, will serve for making the trough, as well as bricks. Iron thus buried in charcoal will undergo no change in the course of 30 years. But charcoal not merely prevents the iron from rusting, for being a very good conductor of electricity, after having been heated to redness (and that is the reason why we recommend the use of baker's ashes), it facilitates the passage of the lightning into the ground.

After leaving the trough, the conductor passes through the side of the well, and descends into the water to the depth of at least two feet below the lowest water line. The extremity of the conductor usually terminates in two or three branches, to give a readier passage to the lightning into the water. If the well be situated in the interior of the building, the wall of the latter must be pierced below the surface of the ground, and the conductor passed through it into the well.

If there be no well at hand, a hole must be made in the ground with a six inch auger to the depth of 10 or 15 feet, and the conductor passed to the bottom of it, placing it carefully in the centre of the hole, which is then to be filled up with baker's ashes rammed down as hard as possible all round the conductor. But if expense be no object, it is better to sink a much wider hole, E′ F′, at least 16 feet deep (unless water be met with at a less depth), and make the extremity of the conductor terminate in several branches, which must be surrounded by charcoal as before, if not immersed in water, and the conductor itself be similarly surrounded by it, by means of a wooden case filled with the ashes.

In a dry soil, or on a rock, the trench to receive the conductor should be at least twice as long as that for a common soil, and even longer, if thereby it be possible to reach moist ground. Should the situation not admit of the trench being much increased in length, others, in a transverse direction, must be made as seen at A, figs. 17 and 18, in which small bars of iron surrounded by ashes are placed, and connected with the conductor. In all cases the extremity of the conductor should terminate in several branches, and pass into a wide hole well filled with the ashes or charcoal that has been ignited.

In general the trench should be made in the dampest, and consequently lowest spot near the building, and the water-

gutters made to discharge their water over it, so as to keep it always moist. Too great precautions cannot be taken to give the lightning a ready passage into the ground, for it is chiefly on this that the efficacy of a paratonnerre depends.

As iron bars are difficult to bend according to the projections of a building, it has been proposed to substitute metallic ropes in their stead. Fifteen iron wires are twisted together to form one strand, and four of these form a rope, about an inch in diameter. To prevent its rusting, each strand is well tarred separately, and after they are twisted together, the whole rope is tarred over again with great care. It is attached to the stem of the paratonnerre in the same manner as the bar-iron conductor, by means of the collar B, fig. 15, the ears of which, in this case, are made rather concave in order better to embrace the rope. Instead of a fork, the stanchions which support it over the roof, are terminated by a ring, O, fig. 12, through which the rope passes. At about six feet deep in the ground, it is united to an iron bar, about three-fourths of an inch square, in which the conductor terminates as seen at C, fig. 16, for the rope would soon be destroyed in the ground. Bars of iron, however, are preferable to the rope, but if, from peculiarity of situation, it be absolutely necessary to adopt them, copper or brass wire is a better material for their construction than iron.

If a building contain any large masses of metal, as sheets of copper or lead on the roof, metal pipes and gutters, iron braces, &c. they must all be connected with the paratonnerre, by iron bars of about half an inch square, or something less. Without this precaution, the lightning might strike from the conductor to the metal (especially if there should be any accidental break in the former), and occasion very serious injury to the building, and danger to its inhabitants.

Paratonnerres for Churches.

For a tower the stem of the paratonnerre should rise from about 15 to 24 feet, according to its area; the domes and steeples of churches, being usually much higher than the surrounding objects, do not require so high a conductor as buildings with extensive flat roofs. For the former, therefore, thin stems, rising from three to six feet above the cross or weathercock, will be sufficient, and being light they may easily be fixed to them, without injuring their appearance, or interfering with the motion of the vane.

When difficult to fix, the stem of a paratonnerre for such buildings may even be omitted altogether, and merely the foot of the cross or weathercock be well connected with the ground. This arrangement requires little expense, and is well adapted for country churches. Fig. 23 represents a steeple without any stem to the paratonnerre, its cross being connected with the

ground by means of the conductor which is attached to its foot. Fig. 24 is a steeple with the paratonnerre stem fixed to the cross. Churches not defended by a paratonnerre on the steeple, require stems from 15 to 24 feet high, similar to that of a flat building.

Fig. 25 represents a paratonnerre so constructed as to be ornamental, with a vane, &c.

Paratonnerres for Powder Magazines.

These of course require to be constructed with the greatest care, but in principle are perfectly similar to the one we have described at length. They should not be placed on the buildings, but on poles at from 6 to 10 feet distance, fig. 26. The stems should be about seven feet long, and the poles of such a height, that the stem may rise from 15 to 20 feet above the top of the building. It is also advisable to have several paratonnerres round each magazine. If the magazine be in a tower, or other very lofty building, it may be sufficient to defend it by a double copper conductor, A B C, fig. 27, without any paratonnerre stem. As the influence of this conductor will not extend beyond the building, it cannot attract the lightning from a distance, and yet will protect the magazine, should it be struck. A common magazine, or any other building, may be defended in a similar manner, fig. 28.

Paratonnerres for Ships.

The stem of the paratonnerre for a ship, fig. 29, consists merely of the copper point, A C, fig. 4, already described. It is screwed on a round iron rod, C B, fig. 30, which enters the extremity, I, of the pole of the top gallant mast, and carries a vane. An iron bar, M Q, connected with the foot of the round rod, descends down the pole, and is terminated by a crook, or ring, Q, to which the conductor of the paratonnerre is attached, which, in this case, is formed of a metallic rope, and is supported at intervals by rigging, *g g*, fig. 29, and after having passed through a ring, *b*, fixed to the chains, is united to a bar or plate of metal, which is connected to the copper sheathing on the bottom of the vessel. Small vessels require only one paratonnerre; large ships should have one on the mainmast and another on the mizenmast.

General Disposition of Paratonnerres on a Building.

It is allowed from experiment, that the stem of a paratonnerre effectually defends a circle of which it is the centre, and whose radius is twice its own height, from lightning. According to this rule, a building 60 feet long, or square, requires only a single stem of 15 or 18 feet, raised in the centre of the roof, figs. 14 and 17. In fig. 17, the conductor is a metallic rope.

A building of 120 feet by the same rule, would require a stem of 30 feet, and such are sometimes used ; but it is better, instead of one stem of that length, to erect two of 15 or 18 feet, one placed at 30 feet from one end of the building, the other at the same distance from the other end, and consequently 60 feet apart from each other, fig. 18. The same rule should be followed for three, or any greater number of paratonnerres.

For churches with steeples, although the paratonnerre on the latter must from its great height extend its influence to a considerable distance, yet as nothing decisive is at present known from experiment as to the greatest distance to which it may extend, it will be prudent to consider it as only protecting a space, whose radius is equal to the height of its stem above the ridge of the roof, and to erect other paratonnerres, on the roof itself, according to the rule already given (see figs. 19 and 20).

General Disposition of the Conductors of Paratonnerres.

Although the necessity of establishing a very intimate communication between the paratonnerre and the soil has already been repeatedly insisted on, its importance is such that it may be well to revert once more to the subject. If this condition be not rigorously observed, the instrument will not only become much less efficacious, but even dangerous, by attracting the lightning without being able to convey it to the ground. What other conditions remain to be stated are less important, but nevertheless deserve attention.

The lightning should always be conducted by the shortest possible road from the stem of the paratonnerre to the ground.

Agreeably to this principle, when two paratonnerres are placed on a building, and terminate in one common conductor (which is quite sufficient), the point from which its branches diverge to the two stems, should lie evenly and at equal distances on the roof between them; the common conductor and its branches may be formed of an iron bar, of the same dimensions as for a single paratonnerre (see figs. 18 and 19).

If there be three paratonnerres on a building, it will be prudent to give them two conductors, fig. 20. In general each pair of paratonnerres requires one conductor.

Whatever number of paratonnerres be placed on a building, they should all be connected together by establishing an intimate communication between the feet of all their stems, by means of iron bars of the same dimensions as those of the conductors, figs. 20, 21, 22.

When the situation will admit of it, the conductor should be placed on the wall of the building most exposed to the rain, which, by wetting it, renders it, though imperfectly, a conductor, and if the conductor of the paratonnerre be not in intimate communication with the ground, it is possible that the lightning

may abandon it for the wet surface of the wall. A further motive for selecting this side of the building is, that the direction of the lightning may be determined by that of the rain, and moreover, the wet surface, being a conductor, may attract the lightning by preference to the paratonnerre.

Observations on the Efficacy of Paratonnerres.

The experience of fifty years demonstrates that when constructed with the requisite care, paratonnerres effectually secure the buildings on which they are placed from being injured by lightning. In the United States, where thunder storms are much more frequent and formidable than in Europe, their use is become general; a great number of buildings have been struck, and scarcely two are quoted as not having been saved from the danger. The apprehension of the more frequent fall of lightning on buildings armed with paratonnerres is unfounded, for their influence extends to too small a distance to justify the idea that they determine the lightning of an electric cloud to discharge itself on the spot where they are erected. On the contrary, it appears certain from observation, that buildings furnished with paratonnerres are not more frequently struck than formerly. Besides, the property of a paratonnerre to attract the lightning more frequently, must also imply that of transmitting it freely to the ground, and hence no mischief can arise as to the safety of the buildings.

We have recommended the use of sharp points for the paratonnerres, as having an advantage over bars rounded at the extremity, by continually pouring off into the air, whilst under the influence of a thunder cloud, a current of electric matter in a contrary state to that of the cloud, which must probably have some effect towards neutralizing the state of the latter. This advantage must by no means be neglected; for it is sufficient to know the power of points, and the experiments of Charles and Romas with a kite flown under a thunder cloud, to be convinced that if sharp pointed paratonnerres were placed in considerable numbers on lofty places, they would actually diminish the electric matter of the clouds, and the frequency of the fall of lightning on the surface of the earth. However, if the point of a paratonnerre should be blunted by lightning, or any other cause, we are not to suppose, because it has lost the property we have mentioned, that it has also become ineffectual to protect the building it is intended to defend. Dr. Rittenhouse relates, that having often examined the points of the paratonnerres in Philadelphia, where they are very frequent, with an excellent telescope, he has observed many whose points have been fused; but that he never found that the houses on which they were erected had been struck by lightning since the fusion of the points.

Article V.

Reply to X. By J. F. Daniell, Esq. FRS. &c.

(To the Editors of the *Annals of Philosophy*.)

GENTLEMEN, *Nov.* 6, 1824.

The illustration of your correspondent X. is so extremely apposite, that I at once agree with him in thinking it conclusive. I suppose, with him, "three barometer tubes standing in a reservoir, and filled alike with mercury, but that one of the tubes *expands* by heating, that another *contracts*, and that the third neither expands nor contracts." But then, I pretend to say (in defiance of the *odium philosophorum*), that if this apparatus be exposed to various temperatures, the columns in all will not rise to precisely the same height *as measured upon their respective tubes*.

X. does me too much honour in supposing that I am the first who ever used the fraction of the apparent dilatation of mercury for correcting the observed height of the barometer: it has long been known to all those moderately acquainted with the subject, that the expansion of the scale must be taken into account for all nice purposes.

I trust that X. will not wait for my visit to the Grampian Hills to disclose his method of detecting "the most minute impurity existing in mercury by inspection of a single drop of that metal," but that he will be induced, for the good of science, to communicate so important a discovery to the *Annals of Philosophy*.* I remain, Gentlemen, faithfully yours,

J. F. Daniell.

Article VI.

Account of a new Mineral Substance. By M. Lévy, MA. of the University of Paris.

(To the Editors of the *Annals of Philosophy*.)

GENTLEMEN, *Nov.* 10, 1824.

You will, perhaps, be able to spare room in the next number of the *Annals of Philosophy* for a short description of a new mineral substance, which I propose to name Rosélite, in honour of Mr. Gustavus Rose, of Berlin.

The only specimen where I have observed it belongs to Mr. Turner's collection. It occurs in small well-defined translucent crystals of a deep rose colour, on amorphous greyish quartz.

* We concur heartily in the wish expressed by our friend Mr. Daniell.—C. and P.

Fig. 1.

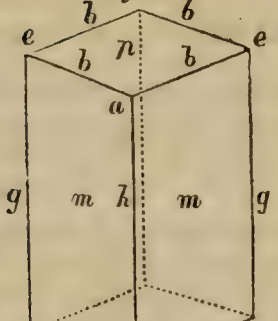
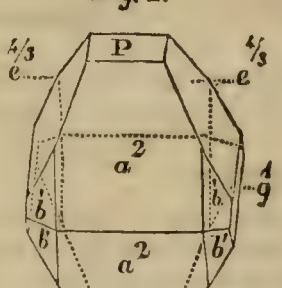


Fig. 2.



The form of the crystals is represented by fig. 2, but the plane marked g^1 is wanting in most of them. There is a distinct and brilliant cleavage parallel to p, but I could not find any other. The hardness of the substance is about the same as that of carbonate of lime. The faces a^2 are dull, and, as it were, hollowed towards the middle: their determination has been deduced from the parallelism of their intersections with the faces b^1. All the other faces are sufficiently brilliant to obtain their incidences by means of the reflecting goniometer. From these incidences, as well as from the different characters of the faces a^2, $e^{\frac{4}{3}}$, and the occurrence of the face g^1, without the edge of intersection of the faces a^2 being replaced, I was enabled to infer that the primitive form was not, as I had thought at first, an octohedron with a square base, but might be supposed to be an octohedron with a rectangular base, or more simply a right rhombic prism. This last hypothesis I have adopted, and determined the dimensions of the prism by assuming that the faces b^1 are the result of a decrement by one row on the edges of the base of the primitive.

In this supposition the primitive form, fig. 1, is a right rhombic prism of 125° 7′, in which one side of the base is to the height nearly in the ratio of 13 to 29. The face a^2 is on account of the parallelism already mentioned, the result of a decrement by two rows on the angle a of the primitive, and the face $e^{\frac{4}{3}}$ on account of its incidence on p, the result of a decrement by four rows in breadth and three in height on the angle e.

The incidences I have taken as data are,

$$p, b^1 = 109° 40' \quad p, e^{\frac{4}{3}} = 112° 30' \quad b^1, e^{\frac{4}{3}} = 129°$$

and I calculated the following, which very nearly agreed with my observations.

$$b^1, b^1 = 114° 24' \quad b^1, b^1 = 79° 15' \quad p, a^2 = 113° 36'.$$

$$m, m = 125° 7'.$$

The specimen comes from Schneeberg, in Saxony, but must of extreme scarcity, being the only one ever seen by Mr.

Heuland. Its great resemblance with the arseniate cobalt from the same locality had hitherto caused its being placed with it.

Chemical Examination of Rosélite. By J. G. Children, FRS.

In glass matrass, decrepitates and gives off water; the fine deep rose colour changes to black.

With borax, on the platina wire, and in the oxidating flame, the assay dissolves readily, and gives an intensely deep blue glass. In the reducing flame, the colour becomes lighter; no appearance of reduced copper.

With salt of phosphorus on the platina wire, the assay dissolves readily and completely, and gives results similar in both flames to those with borax.

The assay dissolves with facility in muriatic acid, and, after evaporation to dryness, the residuum is wholly soluble in water.

A minute fragment digested in a solution of caustic potash, on a slip of glass, evaporated to dryness, redissolved, and the alkali neutralized with nitric acid, gave with nitrate of silver and ammonia, a brown red precipitate of arseniate of silver.

Another minute fragment gave with a drop of muriatic acid a fine blue solution; by dilution with water, the colour disappeared. A drop of the diluted solution gave an abundant precipitate with oxalate of ammonia.

Another drop, evaporated to dryness on a polished steel blade, left no trace of copper.

Another drop gave with prussiate of potash a yellowish green tint, without any indication of copper.

Another drop, treated with bicarbonate of ammonia and phosphate of soda, gave decided evidence of the presence of magnesia.

These experiments are sufficient to show, that the composition of Rosélite consists of arsenic acid, united to oxide of cobalt, lime and magnesia, elements which, according to Phillips (Mineralogy, p. 178), constitute the *Picropharmacolite* of Stromeyer, who found their proportions to be:

Lime	24·64
Magnesia	3·21
Arsenic acid	46·97
Oxide of cobalt	0·99
Water	23·97
	99·78

The whole quantity of Rosélite that M. Lévy could afford me for my experiments, consisted of three or four minute crystals, about the size of a small pin's head, so that any attempt to ascertain the relative quantities of the ingredients would have been

absurd. Judging, however, from the results obtained by the blowpipe, and the appearance of the precipitates, the respective quantities of magnesia in Rosélite and Picropharmacolite, in proportion to those of the lime, must be nearly alike, but that of the oxide of cobalt much greater in the former than in the latter mineral. As the results obtained by M. Stromeyer do not well accord with any probable atomic proportions, some error may, perhaps, have crept in, in the course of his analysis, which even his acknowledged ability may have failed to detect.

Article VII.

On the rapid Descent of the Barometer in Oct. 1824.

By M. P. Moyle, Esq.

(To the Editors of the *Annals of Philosophy*.)

GENTLEMEN, *Helston, Oct.* 30, 1824.

Being struck with the rapid descent of the barometer in the early part of this month, and its accompaniment by a thunder storm, I take the liberty in sending you an extract from my meteorological journal on that occasion, and am,

Gentlemen, your obedient servant,

M. P. Moyle.

1824.	Barometer, corrected to 32° Fahr.	Ther.	Hyg.	Wind.		
Oct. 9.						
9 a. m.	29·6820	55	93	NW	Gentle	Very fine
3 p. m.	29·7127	59	82	W	Brisk	Showery
10 p. m.	29·6664	58	96	W	Gentle	Cloudy
Oct. 10.						
8 a. m.	29·2640	56	98	SE	Very brisk	Rain
2 p. m.	28·1160	59	83	NW	Ditto	Fine
5 p. m.	28·9905	56	86	S	Ditto	Cloudy
8 p. m.	28·9007	55	91	S	Ditto	Clear
10 p. m.	28·8150	55	90	S	Stormy	Cloudy
midnight	28·7647	55		SW	Stormy	Heavy rain, lightning, &c.
Oct. 11.						
4 a. m.	28·4089	57	92	SW	Boisterous	Thunder and lightning
8 a. m.	28·4976	57	91	SW	Ditto	Showery
11 a. m.	28·6620	57	65	S	Fresh	Slight showers
3 p. m.	28·7921	48	86	E	Ditto	Showery
10 p. m.	29·1166	49	93	E	Very fresh	Showery

Article VIII.

Observations on Naval Architecture. By G. Harvey, Esq. FRSE.

(To the Editors of the *Annals of Philosophy.*)

GENTLEMEN, *Plymouth, Nov.* 6, 1824.

In the *Annals of Philosophy* for October, Col. Beaufoy, with his usual zeal for advancing the naval interests of his country, has favoured us with a paper on the experimental ships lately built according to the plans of Sir Robert Seppings, Professor Inman, and Capt. Hays; and has expressed a hope, that this attempt to increase the stock of our information respecting naval architecture, by facts drawn from accurate and unquestionable experiments, may be productive of all the benefits to this important branch of knowledge which the most sanguine of its cultivators may desire. In this hope I most cordially and heartily join; and so doubtless must every well-wisher of his country.

In the same paper, the learned gentleman has also referred to the important subject of the *resistance of fluids*, and to the advantages likely to result to naval architecture, by the institution of a judicious course of experiments; and it is to this part of his communication that I wish more particularly to refer on the present occasion.

The *practical* information we possess respecting the resistance of fluids, is unfortunately very limited and confined; and considering the immense importance of the subject, and the intimate connexion it bears to ship building, it is most singular, that during a period distinguished for uncommon experimental activity, scarcely an effort should have been made to place it on a level with those interesting departments of science to which it is so intimately allied, both from its interesting practical applications, and the fine analytical investigations to which it is likely to give birth.

Had the subject been one which *individual* industry and talent could have successfully prosecuted, there can be no doubt but its complete solution would have been long ago achieved, or at least some large and important steps made towards its completion. But unfortunately, for the sake of science, and, I may add, unfortunately for the naval service of the country also, this is not the case. The problem is one, in the point of view in which Col. B. is probably desirous of contemplating it, involving too many difficulties for an individual to contend with, unless that individual possessed talents of the highest order, uninterrupted leisure, and the necessary command of money;—three elements, I believe, not often united in the same person; and as the past has not afforded a fortunate example of the

kind, we may almost fear the future will not be more propitious.

This great problem, with all its important applications, may, therefore, always remain in its present imperfect condition, unless the necessary funds for its investigation be afforded by the country; and judicious and proper persons be selected for its investigation. It is not indeed too much for the man of science to expect, that some steps at least should be taken towards its completion, when he reflects on the national benefits likely to result from it, by the new aspect it would give to naval architecture, and the important practical rules that would most probably be deduced, to improve the form and the sailing qualities of our ships of war. We may hope indeed, from the liberal spirit which now animates our Public Boards, and from the various improvements which have been latterly introduced into our dock yards, that the difficulties which have hitherto impeded the march of this important branch of knowledge, may be in some degree surmounted; and by a steady perseverance, that all the elements of the problem may be crowned with a perfect and satisfactory solution.

In speaking of this important branch of knowledge, I would not be understood to overlook the splendid efforts which have been already made by mathematicians, to enlarge and extend its boundaries. On the contrary, I cannot too much admire the attempts of that noble race of men to increase our stock of information on the subject, in spite of the clouds and difficulties which surround it. Talents indeed of the most splendid order have been engaged on it; the most beautiful and varied invention has been displayed, and the richest treasures of analysis been unfolded, to elucidate the theories which have been from time to time advanced. Mathematicians, however, have not failed from lack of talent, or want of ardour, to pursue the question in all its bearings, but for want of *experimental data* on which to ground their investigations. It cannot be concealed, that there are difficulties in the way of this problem, which no calculus can reach, however refined may be its principles, or however ample and extended may be its powers, unless *experiment* previously furnishes its properly corrected elements. With these, the mathematician would be enabled to work with the same certainty and success as distinguish his efforts in so many other departments of physical science. Nor can it be till then that ship building can assume a character suited to the genius and scientific intelligence of the age. No longer the sport of accident, and guided by rules, if rules they may be called, which have no other authority and foundation than what an imperfect experience has afforded, we shall see it gradually assuming a new aspect; and instead of having to contemplate

the immense variety of *external forms*, which our harbours and naval arsenals now present, we shall find every ship possessing a figure adapted precisely to her class, and to the peculiar purposes for which she was primarily intended.*

With respect to the proper mode of conducting such experiments, supposing the undertaking to be sanctioned by the Admiralty, one of the dock yards would of course be selected from the numerous facilities which such an establishment must afford. But no little consideration would be necessary in the selection of the proper persons to conduct the investigation. *Practical knowledge alone would be insufficient; nor would the highest theoretical skill be all that would be required. The two must be united,—cordially and harmoniously united. Practice must not decline the assistance of theory, nor must theory disdain to be taught by the lessons of practice; and every result must be deduced from as wide and as extended a basis, as the maturest consideration may deem proper.*

It is truly of importance to improve to the utmost the sailing qualities of our navy, and the money that may be bestowed on it, *cannot* be more properly employed. At present few fixed or determinate principles exist on the subject; and various interesting problems present themselves for investigation on its first consideration. The best figure of the bow, so as to unite every necessary and proper quality for dividing the fluid in which it moves with the necessary capacity for stowage, has never been determined; nor has the figure or position of the middle section been discovered; and it is not too much to say, so far as the practical details of the subject are concerned, that at the present moment *all* is darkness and uncertainty; and in darkness and uncertainty the subject must remain until such experiments are undertaken. Some experimental attempts have indeed been made to elucidate the problem, and to give something like a practical aspect to its investigation; but they have been either too limited or confined, or too little attention has been bestowed on some of its most essential conditions.

Amidst the general efforts for improvement that are now taking place, the improvement of the sailing qualities of our ships of war, and of the vessels of our mercantile marine, is of paramount importance. By the former, as Colonel Beaufoy has judiciously observed, a colony may be conquered, or a valuable settlement saved, by the celerity of the ships employed in the expedition; and for the latter, it may be added, swiftness of

* I exempt from this censure the efforts that have been made by Sir Robert Seppings to improve naval architecture; since every one conversant with the subject must be aware, that the introduction of the diagonal trusses, the improved bows, and circular sterns, mark the first dawn of scientific improvement in our dock yards. The opposition, however, that the introduction of his plans experienced, proves the truth of the observation in the text; and nothing but his commanding talent and power enabled him successfully to surmount it.

sailing, combined with the proper capacity for stowage, is of no less importance. At no antecedent period did so many ships navigate the uncertain bosom of the deep. Every nation almost is aiming at a maritime character, and the sea is become one of the high roads of civilization. To the first maritime people on earth, the improvement of naval architecture addresses itself with peculiar force, and with higher claims to attention, than any other.

George Harvey.

Article IX.

On the Temperature of Mines. By M. P. Moyle, Esq.

(To the Editors of the *Annals of Philosophy.*)

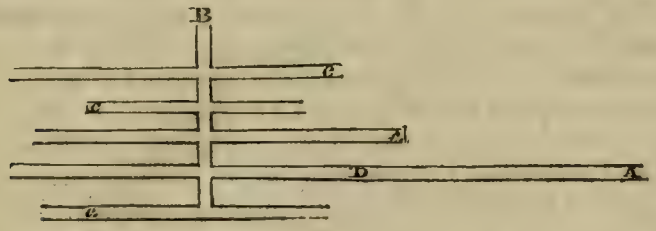
GENTLEMEN, *Helston, Oct.* 30, 1824.

In consequence of my having communicated to the *Annals* some experiments and remarks on the temperature of mines, involving the disputed subject as to the natural heat of the internal strata of the earth, I conceive that your readers are entitled to whatever additional proofs I may be enabled to advance in support of my original opinion, although it forms the substance of a paper read before the Royal Geological Society of Cornwall at their last anniversary meeting.

Perhaps the minds of most of your readers have been made up as to the probability of one or the other theory, deduced from the experiments already detailed in the *Annals*, and which have been tried in this county within the last two or three years. I shall in the first instance endeavour to prove the dubiousness of the one conclusion in a tenfold degree over that of the other, for the high temperatures observed at the bottom of mines, must be, and indeed is, acknowledged on all sides, much influenced by local causes, not easily got rid of, or allowed for; whereas, on the other hand, the low degrees of heat sometimes met with, seems to be beyond the pale of uncertainty; and if we can adduce a solitary instance only of temperature not exceeding the annual mean of the climate, at a considerable depth below the surface of the earth, and more particularly beneath the level of the sea, I shall be apt to infer a difficulty insurmountable by my opponents.

I would suggest that in all endeavours to elucidate this subject, our main object, in proving the correctness of either theory, should be in obtaining the coldest situations possible, instead of those possessing a high temperature, for the presence of workmen, the boring and blasting of rocks, the burning of candles, &c. together with the lengthened column of the atmosphere, must much influence the latter cause, while no operation with

which we are acquainted, but that of evaporating, can by any possible chance controul the first. Hence if a low temperature is met with, it would seem to be a more true criterion of the actual state of the earth generally than we could possibly infer from occasional instances of high temperature, because, were the internal strata of the earth augmented in temperature according to the descent, the emanation of whose caloric is said to be sensible in our mines, a low degree of heat could in no one instance occur. The act of boring holes in the solid rock at the bottom of the mine, or in any other situation, to observe the temperature, must be fallacious; unless the hole is bored to a considerable depth, and in the course of the lode, so that a body of water shall issue in a full and powerful stream *through* it. The heated air of the spot must penetrate, and the sides and bottom of the hole soon acquire the same temperature as the external walls of the gallery itself. This circumstance I have so often proved, that I have always omitted the results as being deceitful. The only way in which this experiment can succeed, so as to supply a true data, appears to be in the manner just stated, with the proviso that the end of an extensive gallery, or some other situation, is chosen the most remote from any working part, and far beyond the perpendicular from the galleries which lie above it as at A. B the perpendicular shaft. *c c c c* are various galleries.



Now if a hole is bored horizontally at A, on the course of the lode, and so as to allow a full stream of water to pass through it, it will be less liable to be influenced by the percolation of the water from the galleries above it; whereas should it be done in any part at D, and there should exist a solid barrier of earth from that place to the gallery above it, the water which lodges at the bottom of the superincumbent gallery generally finds its way perpendicularly to D, and consequently must bring with it a medium temperature of what it possessed before, and that of the stratum of earth through which it has passed, while the water at A most probably will be free from all these objections.

Bearing in mind these circumstances, I shall proceed to detail a few experiments which I performed in the course of the last

summer, and to which I referred in my last communication.* I there stated the temperature of Oatfield engine shaft 182 fathoms from the surface, to have been whilst at work 77°, and in a few months after that period, when this part had ceased working, and all below was full with water, to be only 66°, and the water at 12 fathoms in depth 67°. This mine has now been relinquished for many months, and on sinking a registering thermometer, properly secured, as in my former experiments, to precisely the same depth, the temperature was found to be only 54°, and this degree of heat was uniform throughout the water. Thus adding to the number before given of the conformity of temperature throughout relinquished mines, and evincing upon the grounds before stated† that did the earth in reality possess a natural and a greater heat, the temperature of 54° could not exist.

I also stated the temperature of the water in the then relinquished mines of Herland and Huel Alfred, the former 54°, and the latter 56°. The reworking of these mines has since taken place, and the following are the experiments made on the occasion. The water in Herland engine shaft, being drained 20 fathoms below the adit, making 52 fathoms from the surface, was found to be 58°, while at 8 or 10 fathoms below the surface of the water, it was still 54°. The mud in a gallery at this level was also 54°, while the air was, as in the shaft, 58°. Experiments of this nature were tried as opportunities occurred in the draining of this mine. Few of the galleries could immediately be penetrated to any considerable distance on being first exposed, in consequence of being choked from various causes; but in no one instance was the mud found to exceed 56° of temperature, where immediate access could be had, and previously to the approach of workmen; while the air of the galleries generally approached to within 1° of that in the engine shaft. The surface of the water in the shaft gradually increased in temperature as it descended, so that after having drained 100 fathoms of water, it was found to be 66°, while at 10 fathoms in depth it still retained its former standard of 54°. Experiments of precisely a similar description were carried on at Huel Alfred from its recommencement. They had in September last accomplished the draining of more than 100 fathoms in depth, and no opportunity was lost in proving, by every possible method, the accuracy of the experiments, because they appeared to differ in some respects from those of Herland.

Huel Alfred was formerly found to be at all depths 56°, two degrees above the water in the old engine shaft at Herland, but on an equality with another.

* *Annals*, vol. v. p. 31, N. S. † Ibid.

Most of the levels, &c. were tried in a similar manner to what has just been stated, and the mud was always found to be 56°, so also was the water 8 or 10 fathoms below its surface. The surface of the water in this mine as well as the air never exceeded 59° throughout its descent, being only an increase of 3°, although the water was originally 2° warmer than that of Herland, while Herland increased 10° in draining to the same depth. The reason for this appears to arise from the rapidity with which Huel Alfred engines raised the water in comparison with that of the other. Huel Alfred doing more in one month than Herland did in five or six, consequently the surface of the water in the shaft had less time to be exposed to the operation of local causes.

I caused two holes to be bored in the lode at Huel Trumpet tin mine; one in the end of the 80 fathoms level, and the other in the 94 from the surface. They were each two feet in depth, and so situated that the water should flow through them. These spots were selected because they yielded the greatest quantity of water, and because they extended to the greatest distance, and consequently most free of all the levels from the draining of the water from the superincumbent ones. The 80 extended many fathoms beyond the deeper one, and yielded its water in a very powerful stream *through the hole.* The temperature of this water at the bottom of the hole was only 52°, and that at the 94 under similar circumstances, was 56°. A short intermediate gallery was in full work, and no doubt influenced the temperature of the water in the one below, as all the water of this gallery was found to enter the ground, and doubtless filtered to the one beneath.

If further proof was required as to the similitude of temperature soon acquired by water, it may be found in Capt. Parry's late voyage to the north, where he tried the temperature of the sea at various and considerable depths. In lat. 59·26 he sunk a registering thermometer to the depth of 2100 feet, and the temperature was found to be 50½°, precisely similar to what it indicated at and near the surface, while the air was 53°.

Having now adduced so many instances of temperature at and near the annual mean of this climate, and that at considerable depths even below the sea level, I leave it to be confuted, or to have a clear demonstration why those low degrees of heat should exist.

I am, Gentlemen, your obedient servant,

M. P. Moyle.

Article X.

On Fluoric Acid, and its most remarkable Combinations.

By Jac. Berzelius.

(*Continued from* p. 343.)

II. *Compounds of Fluoric Acid with Acids or Electronegative Oxides.*

The fluoric acid is distinguished from every other by its propensity to combine with the weaker acids in such a manner that the latter act as bases; and these compounds again unite with the fluates of the electro-positive oxides, and form with them double salts. These peculiar salts of fluoric acid and the electronegative oxides are farther characterised by this circumstance, that, when in a similar degree of saturation, they are partially decomposed by water; an acid solution being formed, while the negative oxide precipitates in an insoluble state, either uncombined, or in union with a smaller quantity of fluoric acid. During these decompositions, a portion of water combines with the acid, and there is obtained in fact a double salt, in which water acts the part of a base; this water again may be displaced by any of the more energetic bases, and a new double salt is formed, in which both of the bases are metallic oxides. In all cases where, after the decomposition of a neutral fluate by water, an acid fluate remains in solution, we may remark in the latter a strong tendency to form a double salt, by the substitution of a different basis for the water. Perhaps a similar property may be possessed by the neutral salts of other acids, which are in a similar manner decomposed by water: it is not the case, however, with the salts of antimony and bismuth, from which water produces an almost complete precipitation of the oxides. We have long been aware that fluoric acid in union with silica forms a distinct class of salts with the alkalies, such as potash and barytes; but the nature of these compounds has been hitherto misunderstood. In what follows, I shall demonstrate, that although characterised by peculiar properties, they are fundamentally analogous with the fluates of the saline bases.

A. *Fluate of Silica, or Silicated Fluoric Acid, and its Combinations with the Saline Bases.*

The circumstance that silica and fluoric acid have been found existing together in certain combinations, has caused them to be regarded as constituting, while in that situation, a double acid, capable of uniting with bases, and forming with them a class of compounds to which I applied the provisional name of fluosilicates. In reality, however, this compound must be regarded as a fluate of silica, for unless it undergo a previous decomposition,

in which a portion of the silica is separated and replaced by some other basis, which may be either an alkali, an earth, a metallic oxide, or even water, it is incapable of entering into combination with any other substance except a neutral fluate. I have kept the gas in contact for many days with the pulverised carbonates of potash and soda, without the slightest absorption ensuing; and a similar result was obtained with lime and with the bicarbonates of potash, although I expected that the water of crystallization of this salt might have facilitated the combination. On the contrary, the pulverised fluates of the alkalies, earths, and metallic oxides, even when anhydrous, instantly absorb the gas, and become saturated with it at the end of a few hours. Consequently the fluoric acid and silica, when associated in the proportions which constitute the gas, have no tendency to combine with an additional quantity of base; and the class of salts styled fluosilicates, instead of being combinations of a fluate with a silicate, are combinations of fluate of silica with the fluates of different bases.

Quantitative Composition of Fluate of Silica.—The silica precipitated by water from this compound is so voluminous, and is moreover so decidedly soluble in water, that it is impossible to conduct an analysis by this process with any degree of precision. The most advantageous method appeared to be to precipitate the fluoric acid and silica by soda, in the state of the difficultly soluble salt, and afterwards to separate by double decomposition the silica which remains dissolved in the liquid; but this presupposes a knowledge of the double salt, which would obviously render a separate analysis of the gas superfluous. After ascertaining this necessary preliminary, I proceeded to the analysis in the following manner: A quantity of water was impregnated with the gas, until it became converted into a thick coagulum. During the process, the liquid was incessantly agitated, and care was taken to prevent it from ever coming in contact with the conducting tube. The mixture was now thrown upon a filter, and the silica was washed until the filtered liquid ceased to redden litmus paper. Ignited, it weighed 1·263 gramme. No trace of fluoric acid is expelled during the ignition. I consider it necessary to mention this circumstance, because Gay-Lussac and Thenard's experiments might lead to the supposition, that the silica separated by water from the gas is in combination with a smaller proportion of fluoric acid. The filtered acid liquid was mixed with carbonate of soda as long as it effervesced, and the double salt which precipitated was collected upon a balanced filter, washed, and dried in a balanced platinum crucible. It weighed 8·99 grammes, and is equivalent to 3·053 grammes of fluoric acid, and to 2·994 grammes of silica, provided we make the calculation from my former number for the atomic weight of that substance, which, however, is a little

too high. The remaining liquid, together with the last washings of the silica, was supersaturated with carbonate of soda, mixed with a solution of carbonate of zinc in ammonia, and evaporated nearly to dryness. The silica by being thus combined with oxide of zinc, was not only rendered insoluble, but was reduced to so condensed a state that it could be easily washed. The silicate of zinc, after having been kept in contact for some time with hot water, was transferred upon a filter, and washed. It was then dissolved in nitric acid, the solution was evaporated to dryness, and the residue was digested in acidulated water. The silica, which now remained undissolved, weighed, after ignition, 1·297 gramme. The alkaline liquid filtered from the silicate of zinc consisted of a mixture of carbonate and fluate of soda. It was saturated nearly but not completely with acetic acid, and evaporated to dryness. The object of not rendering it fully neutral was to avoid the possible dissipation of fluoric acid during the evaporation. The dry mass was treated with a mixture of alcohol and acetic acid, in order to extract the slight residue of carbonate of soda, and the fluate of soda obtained by this means in a state of purity, was ignited. It weighed 2·912 grammes, equivalent to 0·787 gramme of fluoric acid. Consequently the whole fluoric acid amounted to 3·053 + 0·787 = 3·84 grammes, which had been combined with 5·554 grammes of silica; that is, in the fluate of silica, 100 parts of fluoric acid are combined with 144·6 parts of silica. This number, as will be subsequently shown, is not strictly accurate, yet it is a sufficient approximation to demonstrate that in this compound, the atomic weight of the fluoric acid has to the atomic weight of the silica the same relation which it has to that of the base in all neutral fluates.

One of the objects of this analysis was to ascertain the proportion of silica which is separated from the gas by the action of water; but the considerable quantity of this earth which is dissolved by the water employed in washing it prevented me from placing any confidence in my direct experimental results. I had recourse, therefore, to the liquid which separates spontaneously from a saturated aqueous solution of the gas, as it was obvious that from a comparison of its composition with that of the gas, it would be easy to infer the amount of silica which is deposited. If this liquid be accurately saturated with carbonate of potash, nearly the whole of the acid and silica are precipitated in the state of the insoluble double fluate of silicate and potash, and the remaining fluid, when evaporated to dryness, is found to contain only a mere trace of the same compound. A still more complete precipitation is obtained when the liquid is mixed with an excess of muriate of barytes: here the whole of the acid and silica are precipitated in the state of the double fluate of silica and barytes, and the supernatant fluid contains nothing except

uncombined muriatic acid and muriate of barytes. If the same experiments be made with the dilute acid which is washed from the silica, a similar precipitation of the double salts is obtained, but the remaining liquid uniformly gelatinizes when concentrated, in consequence of the presence of the dissolved silica. Consequently the gas is converted by the action of water into a liquid acid, in which the fluoric acid and silica exist in the same relative proportions as in the insoluble double salts of fluoric acid and silica with potash or barytes. This proportion, as will be subsequently demonstrated, is such, that one-third of the silica is separated and replaced by water. It is obvious, therefore, that this acid can be obtained pure only when concentrated, and that in proportion as the filtered acid liquid becomes diluted, the greater will be the excess of silica which it will hold in solution.

I consider these experiments to have demonstrated: 1st, *That in the gaseous silicated fluoric acid, the acid and silica contain equal quantities of oxygen, that is,* 3 *atoms of acid are combined with* 2 *atoms of silica; and 2dly, That in the formation of the liquid acid, one-third of the fluoric acid loses its silica, and combines with water; that is, it is composed of* 3 *atoms of hydrous fluoric acid and* 2 *atoms of fluate of silica.**

Water absorbs this gas at first with great avidity, but the process becomes more and more tedious, in proportion as the mobility of the liquid is lessened by the deposition of silica. On exposing to the gas a very small quantity of water, 0·1835 grm. in a small balanced glass vessel over mercury, I found that about 48 hours elapsed before absorption had completely ceased. It had now entirely lost its fluidity, and smoked slightly when exposed to the air. The increase of weight was 0·258 gramme; consequently 100 parts of water are capable of absorbing 140·6 parts of the acid gas, or, by abstracting the 27·65 parts of silica which are deposited at the instant of the absorption, 112·95 parts of the liquid acid. I have made many attempts, but unsuccessfully, to obtain the acid in its highest degree of concentration,

* That the latter part of each of these enunciations may be understood, it may be necessary to state that Berzelius considers fluoric acid to be composed of 1 atom of fluoricum (70·34) + 2 atoms of oxygen (200) = 270·34; and silica, of 1 atom of silicium (277) + 3 atoms of oxygen (300) = 577. The compound of fluoric acid and silica which he styles the *fluate*, is that in which the acid and base contain equal quantities of oxygen, or in which 3 atoms of acid are combined with 2 atoms of silica. A much less complicated view of the constitution of these two compounds may be taken by considering, with Dr. Thomson, the atomic weight of fluoric acid to be represented by one-half, and that of silica by one-third, of the numbers adopted by Berzelius. On this supposition, the gas would be composed of 1 atom of fluoric acid + 1 atom of silica; and the liquid acid, of 2 atoms of this simple fluate + 1 atom of hydrous fluoric acid. The formulæ by which Berzelius represents the composition of these two compounds are $\dddot{S}^2\,\ddot{F}^3$ and $3\,\ddot{F}\,Aq^1 + 2\,\dddot{S}^2\,\ddot{F}^3$. The formula by which they would be represented in conformity with the numbers of Dr. Thomson, are $\dot{S}\,\dot{F}$, and $2\,\dot{S}\,\dot{F} + \dot{F}\,Aq$.

that is, containing no water, except the quantity which acts the part of a base. Thus I have distilled the silicated fluate of barytes with concentrated sulphuric acid, but there was disengaged at the commencement of the process a large quantity of the gaseous fluate of silica, which gelatinized in water, and towards the conclusion, there passed over an acid liquid, which consisted in a great measure of concentrated fluoric acid. Even the silicated fluates, such as those of copper or nickel, which contain much water of crystallization, afforded similar results. The dilute acid may be concentrated by evaporation, but after it attains a certain degree of strength, it begins to evaporate in an equal proportion with the water: it may also be concentrated over sulphuric acid in vacuo, but long before it acquires the above-mentioned strength, it evaporates along with the water, and corrodes the receiver. The best method of obtaining this acid in a state of concentration is to add finely pulverised silica in small quantities at a time to fluoric acid, diluted with twice or thrice its weight of water, and artificially cooled. It dissolves the silica readily until it attains the composition of the liquid acid; what it takes up beyond this point is immediately afterwards dissipated in the form of gas.

When the double silicated fluates which contain water of crystallization are exposed in a glass vessel in so high a temperature that the fluate of silica begins to be expelled, there is obtained a white sublimate which might be readily mistaken for an ammoniacal salt, but which, when examined by a microscope, is found to consist of transparent drops. This liquid may be distilled unaltered from one part to another so long as the vessel is filled with the gaseous fluate of silica, but it deposits silica as soon as the gas is replaced by atmospheric air. It requires a pretty high temperature for volatilization.

There is a particular degree of concentration which the liquid acid uniformly acquires when exposed for some time to the air; when weaker than this, the excess of water evaporates; when stronger, it very rapidly absorbs moisture from the atmosphere. In a temperature of about 104°, it slowly evaporates without leaving any residue, and towards the conclusion of the evaporation, it deeply corrodes any glass vessel in which it may have been kept.

The gaseous fluate of silica is rapidly absorbed by alcohol without decomposition, but as soon as the liquid becomes nearly saturated, it stiffens to a clear transparent jelly. The alcohol when saturated contains more than half its weight of the gas, and has an odour of ether. Petroleum also absorbs the gas unaltered, but only in small quantity.

The liquid silicated fluoric acid combines with all the bases, and forms with them peculiar salts. I have subjected to a regular analysis the double salts of potash, soda, barytes, and lime,

and found the constituents in them all to be combined in similar proportions. I believe, therefore, we may conclude, that all the double salts obtained by saturating bases with this acid possess an analogous constitution. I shall here state the details of these analyses. The analyses of the salts of soda and barytes are the most easily executed, and afford the most decisive results.

Silicated Fluate of Soda.—*a.* 100 parts, decomposed by sulphuric acid, gave 74·85 parts of sulphate of soda = 32·844 parts of soda. The sulphate of soda dissolved in water without leaving any residue, and was exactly neutral. *b.* 100 parts dissolved in boiling water were slightly supersaturated with carbonate of soda, and the liquid was mixed with an excess of a solution of carbonate of zinc in ammonia. The whole was now evaporated until the ammonia was expelled, and the silica was separated in the manner which has been already described. It weighed, after being ignited, 31·6. *c.* The filtered alkaline liquid was evaporated nearly to dryness ; the excess of carbonate of soda was saturated with acetic acid, and the acetate of soda was separated by alcohol. The fluate of soda, isolated by this means, weighed, after ignition, 134 parts. As 32·844 of soda is equivalent to 44·2 of neutral fluate of soda, and as 44·2 × 3 = 132·6, it follows that in the double salt the soda is associated with thrice as much fluoric acid as is requisite for its neutralization. It is impossible by this analytical process to separate the silica completely; hence the quantity indicated by the experimental result is always rather less than the truth, while, on the contrary, that of the fluate of soda is slightly in excess.

Silicated fluate of barytes, when ignited in a glass retort, gives a trace of the sublimate already mentioned, which consists of water supersaturated with the acid gas. The expelled gas does not corrode glass, and therefore contains no disengaged fluoric acid. *a.* 100 parts of the salt, in two successive experiments, left, after ignition, 62·25, and 62·26 parts of fluate of barytes. Consequently the fluate of silica which had been expelled, amounted to from 37·74 to 37·75 parts. *b.* 100 parts, decomposed by sulphuric acid, gave 82·933 parts of ignited sulphate of barytes.

Silicated Fluate of Potash.—100 parts were converted by sulphuric acid into 78·85 parts of sulphate of potash = 42·634 potash.

Silicated Fluate of Lime.—100 parts gave with sulphuric acid 63·69 parts of sulphate of lime ; and by strong ignition, 36·2 parts of fluate of lime. Both these quantities represent 26·4 parts of fluate of lime. 100 parts were incorporated with 600 parts of oxide of lead, covered with an equal quantity of the oxide, and exposed to a low red heat. The mixture fused, and gave off 16·25 parts of water. Consequently this salt contains

a quantity of water of crystallization, whose oxygen is double that of the lime.

In other respects, the composition of all these salts is strictly analogous.

The composition of these double salts affords a simple explanation of a phenomenon which at first appears very paradoxical. If a solution of superfluate of potash or soda be digested with as much silica as is sufficient to saturate the excess of acid, it loses altogether its acid reaction, and becomes alkaline. This reaction, however, is not occasioned directly by the silica. The excess of acid in the salt is exactly sufficient to form a silicated fluate of potash or soda with one-half of the neutral fluate: in proportion, therefore, as this excess combines with silica, the double salt precipitates, while the other half of the neutral fluate, which remains in solution, exhibits its characteristic alkaline reaction. Zeise had already shown, that a similar change is produced upon the acid fluates by boracic acid.

The double fluates of silica with the other bases have all an acid bitter taste, which in most instances cannot be distinguished from that of cream of tartar. They all redden litmus paper, and the greater number of them are soluble in water. The only difficultly soluble salts which I found, were those of potash, soda, lithia, barytes, lime, and yttria. Many contain water of crystallization, and a few of them fatiscerate.* In a high temperature they all undergo decomposition, gaseous fluate of silica being expelled, while a neutral fluate of the stronger base remains. If the salts contain water of crystallization, it passes off along with the fluate of silica, and there is obtained a concentrated liquid, silicated fluoric acid, which deposits silica when it comes in contact with water. The quantity of water of crystallization may be determined by heating the salts along with oxide of lead, in which experiment there is formed an actual fluosilicate of the oxide. This compound is so remarkably fusible, that it becomes liquid in a temperature below a visible red heat, particularly when the ingredients are proportioned with some exactness.

The aqueous solutions of these double salts are all of them decomposed by alkalies. The alkaline salts are decomposed in such a manner, that the silica is precipitated, while the acid with which it had been combined remains in solution, in the state of a neutral fluate. From the earthy salts the earth is precipitated in the state of fluate, mixed or combined with the

* This term is applied by Berzelius to certain compounds containing water of crystallization, which lose a determinate quantity of it, but not the whole, when exposed to a temperature considerably under 212°. Thus citric acid, sulphate of ammonia, oxalate of ammonia fatiscerate, when exposed to a low heat, losing by this treatment exactly one-half of their combined water.

silica, whose acid remains in solution. From the salts of the earths proper, and of the metallic oxides, the base is precipitated in the state of a bisilicate, while the whole of the fluoric acid remains dissolved, in combination with the alkali. Even when the metallic oxides are soluble in ammonia, a determinate portion of them is carried down by the silica. When the solutions of certain of these salts are mixed with a less quantity of acid than is requisite to produce complete decomposition, peculiar subsalts are precipitated, but I am uncertain whether these are mixtures of silica with a subfluate, or actual fluosilicates, in which the same base is shared between two acids.

In most cases I prepared these salts by digesting the liquid acid over the carbonate or hydrate of the base, until it was nearly saturated: the solution was then concentrated to a certain point in a flat platinum capsule, and allowed to crystallize of its own accord in a temperature between 64° and 68°. When the gelatinous silica on the filter has been pretty thoroughly washed, so large a portion of it is dissolved, that the solution of the salts prepared from the liquid acid not unfrequently gelatinizes during concentration. This excess of silica may be redissolved by the addition of a few drops of pure fluoric acid, and the compound thus formed is volatilized by the subsequent evaporation in the form of gas. Fluoric acid does not decompose these double salts, and when the mixture is evaporated to dryness, the whole excess of acid flies off, and leaves the salts unaltered.

Sulphuric acid instantly acts upon these double salts, and disengages gaseous fluate of silica: the decomposition is rendered complete by the application of heat, and there is expelled at the same time a quantity of liquid acid, which rapidly attracts moisture from the atmosphere. The salts of lime and barytes are not decomposed by sulphuric acid, except in temperatures above 212°. Nitric and muriatic acids decompose these double salts only partially. On the contrary, the liquid silicated fluoric acid, in the humid way, completely deprives these acids of the bases with which it forms difficultly soluble com pounds; in other cases the decompositions which it also produces are only partial.

(*To be continued.*)

Article XI.

Additions to a Paper in the last Number of the Annals of Philosophy. By William Henry Fitton, MD. FRS. MGS. &c.

(To the Editors of the *Annals of Philosophy*.)

GENTLEMEN, *20th November*, 1824.

I shall be much obliged by your inserting the following paragraphs connected with my paper in the *Annals of Philosophy* for the present month, if possible, in the ensuing number of your journal, that they may be placed in the same volume with the paper to which they refer.

I remain, Gentlemen, your obedient humble servant,

William Henry Fitton.

I had stated in a memoir read at the Geological Society during the last Session,* before I had examined the Isle of Wight, that I was indebted to Mr. Lyell, one of the Secretaries of that body, for complete evidence of the identity of the greenish beds below the chalk between Beachy Head and Sea-Houses, in Sussex, with what I have denominated Firestone, at Culver in the Isle of Wight; and in your last number (p. 381), I have mentioned my obligation to the same gentleman for a section of the beds below the chalk at Shiere, near Guildford, in Surrey. I was not then aware, nor was I till Mr. Lyell's return to London during the last week, fully informed upon this subject, that his observations in the Isle of Wight were more extensive than I at first supposed; since he had not only found at Sandown Bay the calcareous nodules inclosing univalves, which I have mentioned (p. 374), but had deduced from his observations the same inferences respecting the real order of the strata below the chalk, and their correspondence in the Isle of Wight with those of Kent and Sussex, as I have been led to, by considering the features of the surface, and by subsequent examination of the strata. Mr. Lyell's observations were communicated by letter to Mr. Mantell, of Lewes, so far back as in July 1822; and during a tour in the Isle of Wight in the spring of 1823, with the Hon. H. G. Bennett and Prof. Buckland, Mr. Lyell pointed out upon the spot to those gentlemen the facts on which his views were founded: which, as they accord with most of the essential points that I have mentioned, would no doubt, if followed up, have led to the same results.—Had I been informed, as I am at present, of these circumstances, I should unquestionably have mentioned them in my paper; and I now think it is due, both

* 19th June, 1824.—See p. 67 of the present volume.

to Mr. Lyell and to myself, to acknowledge unequivocally the priority of his observations and deductions.

I take this opportunity also of correcting an omission of importance, and some errata in that part of the table at the end of my paper, which refers to Prof. Sedgwick's valuable memoir in the *Annals of Philosophy* for May, 1822.* The first three divisions of the column under Mr. Sedgwick's name should stand thus :—

Beds as they exist in the Isle of Wight.	*Sedgwick.*
1. Chalk, with flints. without flints. grey (marly). bluish.	} Chalk. " Indurated chalk marl."
2. Greenish sand and sandstone, with chert.(*Firestone.*)	In the Isle of Wight, " greensand." In Cambridgeshire, " a very thin bed of tenacious blue clay, which is mixed with greensand, and contains a great many fossils."
3. Clay of the undercliff. (*Gault.*)	In the Isle of Wight, considered as the same with the *weald-clay*, No. 5. In Cambridgeshire, " tenacious blue clay. (*Gault.*)"

I have intimated in the concluding paragraph of my paper (p. 383), the probability that the order of the strata now recognised in the Isle of Wight would serve to clear up the obscurity, in which some other districts, consisting of the beds below the chalk, have been hitherto involved ; and it is obvious, that as the firestone has been frequently confounded with the lower beds, and the Hastings sands with the upper ferruginous portion of the greensand,—and the gault with the weald clay, it will be necessary again to examine the strata to which any of these names have been applied, for the purpose of deciding upon their true relations.—It seems to be highly probable, from Mr. Smith's geological maps of Berkshire, Oxfordshire, Buckinghamshire, and Bedfordshire, that a part at least of what has

* Mr. Sedgwick has himself been so obliging as to point out these inaccuracies in the Table, which were, in part, occasioned by an oversight of the person who transcribed the paper for the press. The order of the beds in the vicinity of Cambridge, corresponds precisely with that of the Isle of Wight and of Sussex.

been denominated "*iron sand*," in those counties, and regarded as the equivalent of the Hastings-beds, belongs in reality to the greensand of the Isle of Wight: since the outcrop of the chalk is continued without interruption through the tract just mentioned, with firestone in several places immediately below; and a bed of clay is also represented as being continuous and parallel to the chalk throughout,—with the sands containing "carstone," likewise in continuity, immediately beneath it:—just as in the counties of Surrey, Kent, and Sussex.*

It deserves inquiry, therefore, whether that part of the range of sands passing through Oxfordshire, which shoots beyond the general line to Shotover Hill, may not also belong to the greensand;—the Tetsworth-clay in the same county, which has generally been considered as the equivalent of the weald-clay, being expressly identified by Mr. Smith with the gault of Cambridgeshire.—In Buckinghamshire, the sand below the gault is continued towards the north-east, from Thame to Woburn, but the true nature of the portions which are most remote from the gault seems more doubtful; and some of these may possibly be referable to the Hastings sands.—In Bedfordshire, the sands adjoining the gault would seem to belong to the Shanklin-beds; but the place of some detached portions of clay, in the midst of the sands of this county, corresponds with that of the weald-clay, and would consequently lead to the expectation of the true Hastings strata on the north-western verge of this sandy district.—In Norfolk, the tract of sand which extends with an irregular outline from near Downham to the sea at Hunstanton, ranging nearly parallel to the chalk, and bearing upon it several detached portions of blue clay with the characteristic belemnite of the gault (see Smith's map), seems to be referable to the Shanklin sands.—In Lincolnshire from Spilsby to near Barton, a similar remark may be applied.—And in the south-east of Yorkshire, the long range of the chalk from the north bank of the Humber to the shore on the south of Filey Bay, is succeeded by sands, and these again by clay, the true relations of which are still to be ascertained.

An examination of the Ordnance Surveys, and of the geological maps of the south-eastern counties, Wiltshire, Dorsetshire, and Devon, in which the structure of the surface is more com-

* I have had occasion to remark, that the local division of the beds in Mr. Smith's county maps, is generally correct, in that part of the series which is at present under consideration.—But unfortunately his names and colours are not always applied with consistency; and his erroneous identification of the green-sand of Kent with the Portland sands, and of the Kentish rag with the Portland limestone, has caused his boundaries of the strata also to be considered as erroneous, and thus diminished the usefulness of a very valuable publication. The bed which I have traced in the text from Berks to Cambridgeshire, under the name of *gault*, and which is so denominated in Mr. Smith's county maps, is, in his reduced map of England, named *oak tree-clay*, and identified with the weald-clay of Kent and Sussex.

plex, will make it evident that a great deal is still to be determined respecting the beds below the chalk in those districts.—And since it is probable that a greater consistency of structure than has hitherto been suspected will be found to pervade the whole of the extensive tract now mentioned, even this rapid view of what remains to be done, will show how much there is to reward inquiry in this department of the geology of England.

It has been suggested to me, from different quarters, that the terms *upper* and *lower* greensand would be preferable, for the denomination of the beds which I have named firestone and greensand; and that these two strata, together with the intervening gault, might form one group, in the general arrangement, under the name of "the greensand formation." But the misapplication of the term *greensand* has really been the source of so much confusion, that it seems much better to give it up altogether, and to choose for the beds in question names entirely new.—I know indeed that some of the principal geologists in England concur in this opinion. And the propriety of grouping together the firestone and greensand is also doubtful:—because the firestone beds are not in general separated from the chalk by any well marked natural feature, but pass into the lower part of it almost insensibly. They sometimes, it is true, project beyond the foot of the chalk escarpments so as to form a sort of step or lower plateau, as at St. Catherine's Down in the Isle of Wight;—but there never is between the two strata a well defined valley, such as that which contains the gault, and separates the firestone from the greensand,—a natural and characteristic feature that is seldom wanting. It may be added in support of this objection, that the French naturalists consider the firestone as a variety of the *chalk* itself, and have named it accordingly *craie-tufau*, *glauconie-crayeuse*, &c.

I have employed the term firestone to designate the beds above alluded to, merely for the purpose of distinction; but it is, perhaps, objectionable, inasmuch as the true firestone forms a part only of the beds to which the name of the stratum is intended to refer, and is probably not coextensive with the stratum itself.—The principles of geological nomenclature seem to require, that significant terms derived from external characters should be avoided; since, from the great diversity of composition and appearance which exists in the same stratum in different districts, such terms are very seldom correctly applicable to any great extent:—Of this the greensands, as they have been hitherto denominated, afford a remarkable proof.—The best names, therefore, at present in use, are either those (like gault and lias), which are insignificant themselves, but locally employed, in districts where the strata with which they are con-

nected are strongly characterised and well defined—or those derived from the names of places, where the beds are fully displayed and have been sufficiently examined:—as in the case of the Portland limestone, the Purbeck beds, and the Hastings sands. I am upon the whole disposed to prefer denominations of the last mentioned description, since the very terms themselves point to the types in which the characters of the strata are best exhibited; and if the place which furnishes the name be easy of access, geologists will find no difficulty in recurring to the standard, for the purpose of verification, in doubtful cases.

From these combined considerations, I should propose to distinguish all the strata which form the subject of my last communication by different names; and, for the present, not to group them together. And as the firestone beds are well displayed at *Merstham*, near Reigate, a place within a few hours' journey from London, while the cliffs at *Shanklin* and its vicinity, in the Isle of Wight, exhibit very distinctly almost every form of what has been called greensand,—in a district which must always be interesting to geologists,—I would suggest the adoption of the following series of names, with the hope of preventing ambiguity in future:—

Proposed names of the strata.	*Synonymes.*
1. Chalk	Including *chalk with and without flints*—(the *craie blanche* of the French) and *grey chalk—chalk marl* of Mr. Webster.
2. Merstham beds .	*Firestone.—Greensand* of Mr. Webster, Isle of Wight.—*Tuffeau.—Craie-chloritée* or *Glauconie-crayeuse* of the French.*
3. Gault.....	*Folkstone-marl.—Blue marl* of Mr. Webster in the Isle of Wight.—*Golt-brick-earth* of Smith's county maps.—*Tetsworth-clay?*
4. Shanklin sands.	*Greensand*—commonly so called.—Upper part of the *ferruginous sands* of Mr. Webster.—*Glauconie crayeuse?*
5. Weald clay....	(By some considered as the same with the clay of *Tetsworth*, which, however, is probably the gault?)
6. Hastings sands.	*Iron sands.*—Lower part of the *ferruginous sands* of Mr. Webster, I. of Wight.

* The presence of chert is mentioned by Mr. Brongniart as characteristic of the craie-tufau: but the relations of the Glauconie-crayeuse are rendered doubtful by what the same author has mentioned of its separation in some cases from the Tufau by a bed of bluish clay marl. (See Ann. des Mines, i. 254-5, 257-8, and vi. 550, 547; or the translations in Mr. De la Beche's "Selections," &c. 1824.)

Article XII.

(To the Editors of the *Annals of Philosophy*.)

GENTLEMEN,

Feeling extremely anxious that my reply to Dr. Fitton should be inserted in the *Annals* of this month, I am sorry to find that your previous arrangements have rendered that impossible. Since several geologists are concerned in the question, and may write upon the subject, I trust that my reply will find a place in the next number, and that your readers will suspend their judgment until they read my paper, which is connected only with that by Dr. Fitton already published in your last.

I am, Gentlemen, yours, &c.

T. Webster.

Article XIII.

Answer to Mr. Phillips's Observations on the London Pharmacopœia. By Mr. G. Whipple.

(To the Editors of the *Annals of Philosophy*.)

GENTLEMEN, *London, Aug.* 11, 1824.

In reply to a few of the hints given in the *Annals of Philosophy* for June, by way of improvement on the formulæ constituting the New London Pharmacopœia (1824), I should esteem it an obligation, if favoured with a translation of the first nineteen lines of the paper, the *parvum in multo*.

On the formula for the preparation of sulphate of potash, the writer of the paper is most fatally mistaken. In my opinion, the College have acted most judiciously in directing that the excess of acid be saturated with potash, instead of lime, for, in this instance, they employ a salt of a very inferior value to obtain one of a greater, (and, by the bye, of some considerable importance to every manufacturing chemist), and, therefore, contrary to the opinion of the writer (of that paper), who says, "The College would have acted economically in imitating the directions of the Edinburgh Pharmacopœia, by saturating the excess of acid of the bisulphate, with lime instead of potash; by this the waste would have been avoided of using a salt of greater value to obtain one of less." A single importunity to any of the drug warehouses will convince him of his error. Moreover, I would ask, since economy be the maximum on which he has founded his examination, whether this salt could not be more

economically obtained by employing potash in the process for forming the ferrum præcipitatum.

To attempt a definition of his remark on the preparations of iron, would be *Aquam arare*, wherefore I shall be obliged, if favoured with information, as to its abstract tendency. What must be the inference of an assertion like the following? "That in the preparations of iron, there have been some alterations which are to be considered as amendments; *but I am apprehensive that the good which has been done is more than counterbalanced by the omission of improvements, or the commission of errors.*" Surely, if in the formula, that is, such as have been altered, amendments have taken place, how can we ascribe to the College a want of ability, or the commission of error?

My remark relative to the ferri subcarbonas, will be seen in the note on sulphate of potash.

The acidum aceticum fortius diluted with water does not answer for the purpose of making the liquor plumbi subacetatis. I have frequently tried it, and ever been unsuccessful, for as soon as it assumes the density, as required in the Pharmacopœia, it becomes opaque, which cannot be removed by filtration.

Anticipating the insertion of this paper in the *Annals of Philosophy*, by the which an elucidation of the several paradoxes complained of may be obtained,*

I remain very respectfully, Gentlemen,

Your most obedient servant, G. Whippl E

Article XIV.

Proceedings of Philosophical Societies.

ROYAL SOCIETY.

This Society re-assembled on the 18th of November; when Douglas C. Clavering, Esq. Capt. R. N. was admitted Fellow, and the Croonian Lecture, by Sir E. Home, VPRS. was read: it related to Mr. Bauer's discovery of nerves on both the fœtal and maternal surface of the Placenta: a paper, by the same author, as also read, On the Changes undergone by the Ovum of the wFrog, during the production of the Tadpole. We shall give some account of these papers in the next number of the *Annals*.

LINNEAN SOCIETY.

The first meeting of this Society for the present session took place on Nov. 2; when W. J. Broderip, Esq. was admitted

* I shall probably take some notice of this communication in the next Number.—R. P.

Fellow, and a paper was read, On three Species of Birds, one hitherto undescribed, and the others new to the Ornithology of the British Islands; by N. A. Vigors, Jun., Esq. FLS. We shall present a report of this paper in our next.

GEOLOGICAL SOCIETY.

Nov. 5.—A paper was read entitled "Observations on a Comparison between the Beds below the Chalk in the Isle of Wight, and in the Counties of Surrey, Kent, and Sussex;" by Thomas Webster, Esq. Sec. G. S.

Mr. Webster stated, that in a late visit to the Isle of Wight, he had been so fortunate as to discover a rock of the same nature as the calciferous sandstone of Hastings, a circumstance that has furnished him with a fixed point, by means of which he had been enabled to compare the beds in the Isle of Wight with those of the south-east part of England more correctly than had been done before; and he presented a table of what he considered as the equivalent beds in these two places. He imagined that these equivalents had been hitherto stated erroneously by several geologists; and he attributed this chiefly to the following causes:—1st, The imperfect state of the science of geognosy which had not as yet established fixed principles of classification: 2dly, The want of acknowledged *types* of beds or formations, to which all other parts might be referred: 3dly, The difficulties attending actual examinations, arising from the deficiencies or want of continuity of some beds, and the variation in the composition and structure of others; difficulties which had, in his opinion, been underrated.

The author then proceeded to point out in detail what he conceived to be the history of some of the errors that had been fallen into. Thus, until lately, the descriptions given by various geologists of the rock called *green sand* were supposed to be applied to *one* bed only, whereas, in fact, there are *two* beds distinct from each other, the undercliff of the Isle of Wight, and the rock of Folkstone, each of which had received this denomination. Also in the groups which it had been found necessary to form, they had not agreed with each other as to the individual beds enclosed in one group. Thus, some had formed a group (which they called *the ferruginous sand*) of the sands *above* and *below* the weald clay; while others had attached the name of ferruginous sand to those *below* the weald clay *only*. He had also reason to fear, that an error had been committed in not identifying the beds which are called *the ferruginous sand*, on the west of the chalk, as the Carstone, Wobourn sand, and the Faringdon bed, with the beds in the wealds of Kent and Sussex to which the name of *green sand* had been given.

The following is the table of equivalent beds above alluded to :

Localities in the Isle of Wight.		*Localities in the SE part of England.*	*Names proposed for the Equivalent Beds.*	Groups.
Culver Cliff.		Guildford.	Chalk with flints.	Chalk formation.
—		—	—	
Ditto.		Ditto.	Chalk without flints.	
—		—	—	
Ditto.		Ditto.	Chalk marl.	
Undercliff.		Riegate, Merstham, and Beachy Head.	Upper green sand.	Green sand formation.
—		—	—	
Ditto.		Folkstone Cliff.	Blue marl of the green sand.	
—		—	—	
Redcliff, Atherfield, and Blackgang.		Folkstone, Leith Hill, &c.	Lower green sand, or ferrugino-greensand.	
Sandown Bay and Brixton Bay.		Wealds of Kent and Sussex.	Weald clay.	Not yet named.
—		—	—	
Cowleaze Chine.		Hastings.	Hastings limestone.	
—		—	—	
Sandown, Brook Point.		Hastings and Fairlight.	Hastings sandstones and clays.	
—		—	—	
		Isle of Purbeck.	Purbeck beds.	
		Isle of Portland.	Portland beds.	

Nov. 19.—A paper was read, "On the Purbeck and Portland Beds;" by T. Webster, Esq. Sec. G. S.

The author observed, that the great general features of the geology of the Isle of Purbeck had been already traced out by him in his letters to Sir Henry Englefield. He now confined himself to some details respecting the series of limestone beds in the Isle of Purbeck, and to those in the Isle of Portland.

He then proceeded to give a description of the strata from which the well known Purbeck stone used in London, for side pavements, &c. is derived. This stone is composed almost entirely of fragments of shells. The Purbeck marble contains chiefly univalves in a compact limestone, and these in general are smaller than the univalves in the Petworth marble, both having been supposed to belong to freshwater shells; but the author possessing specimens that contain a mixture of marine with freshwater shells, he cannot consider this as a decided freshwater formation, a term that, in his opinion, ought to be restricted to those beds supposed to have been formed in *lakes only*. The common Purbeck stone appears to consist of fragments of small bivalves, of which the origin is doubtful.

Mr. Webster then gave a detailed account of the quarries in the Isle of Portland, which furnish the Portland stone much

used in our public buildings. The Isle of Portland consists of a mass of limestone lying upon a bed of bituminous clay and limestone identical with the Kimmeridge beds. The lower and more considerable part of the limestone in the Isle of Portland above the Kimmeridge clay, is chiefly oolitic, and contains beds of chert; but the upper part consists of a yellowish calcareous stone nearly compact, which contains in it a bed of earthy lignite abounding in silicified portions of trunks of trees, about two or three feet in length, some of which are erect, and others lie flat. As far as he could ascertain, the fossil wood was nearly confined to this stratum, and is not dispersed through the oolite as had hitherto been supposed. These upper beds of the Isle of Portland he considered as belonging to the same formation as the Purbeck beds, having found some very similar in the Isle of Purbeck.

Considering the fossil shells of the Portland oolite to be marine, while those of the Purbeck limestone are chiefly fresh-water, together with the great difference in the mineralogical character, the author stated his opinion that these two series of beds should be kept in separate groups in classing the English strata.

Article XV.

SCIENTIFIC NOTICES.

Chemistry.

1. *Minerals produced by Heat.*

It has been very often observed, that the analyses of minerals are of comparatively little value, as long as we are not capable of reproducing by composition what had been dissolved. Prof. Mitscherlich has accomplished this important object. We have been gratified by the sight of beautiful and well-defined crystals of greyish white pyroxene, which had been obtained by mixing the constituent parts indicated by analysis in the necessary proportion, and exposing this mixture to the high degree of heat of the porcelain furnaces of Sevres. By this means, Prof. Mitscherlich has succeeded in obtaining several species that occur in nature. He has likewise observed among the different kinds of slags more than forty species in a crystallized state, particularly of such minerals as are found in primitive rocks, but likewise a good many others which have not hitherto been observed. We propose giving in our next number a full statement of the further details of these most important experiments. —(Edin. Jour. of Science.)

2. *Berzelius's Analysis of the Sulphato-tri-carbonate of Lead.*

This eminent chemist, in analyzing some specimens of this

interesting mineral, sent to him for this purpose by Dr. Brewster, obtained the following results:

Carbonate of lead	71·1
Sulphate of lead	30·0
Muriatic acid	Trace
Lime	Trace
	101·1

In the letter with which M. Berzelius has favoured us on this subject, he remarks, that his result accords with that of Mr. Irving, of Edinburgh, who found the carbonate of lead to be 73, and the sulphate 29, giving an excess of 2·0.—(Edin. Phil. Jour. vol. vi. p. 388.) He likewise remarks, that as he had an excess of 1·1 of weight of the stone, it is probable that a part of the oxide of lead in it is in the form of a subsalt. "The result," he adds, "as it is, does not agree with the definite proportions; and the small quantity of the mineral did not permit me to make ulterior experiments."

Mr. Brooke, in his analysis, makes the results agree perfectly with the definite proportions (Edin. Jour. iii. 118), viz. about 72·5 of carbonate, and 27·5 of sulphate of lead. He had no excess of weight, and did not observe either the trace of muriatic acid or of lime.—(Edin. Jour. of Science.)

Mineralogy.

3. *Localities of Scottish Minerals.*

In No. 2 of the Edinburgh Journal of Science, Dr. Macculloch has given a list of localities of some Scottish minerals. Among these several of the substances which formerly belonged to the zeolite family, are incorrectly named. Under *Stilbite* Dr. M. includes a red mineral from Kilpatrick Hills, and a colourless or slightly tinged substance found at Strontian. These minerals differ essentially from each other in their specific characters. The first is described in Phillips's Mineralogy, under the name of *Heulandite*, and the second as *Brewsterite*.

In reference to *Comptonite*, Dr. M. says, "If this be a *new* mineral, it is the supposed stilbite of Strontian;" that is, it is *not* a *new* mineral. But if Dr. M. had ever examined *Comptonite*, and compared it with *Brewsterite*, he would have found sufficiently marked distinctions between them to have prevented his confounding them with each other; and he would also have ascertained that *Comptonite* differed from every other known mineral.

Among the localities of *Nadelstein*, Dr. M. refers to Kilpatrick Hills, and he also includes under this species the *natrolite* from Staffa.

It is evident that Dr. M. has looked at this tribe of minerals

very cursorily, or he could not have erred so widely as he has in arranging them under the heads in which they stand in his list. Is he not aware that *natrolite* and *mesotype* are the same mineral, and that the Kilpatrick mineral differs both from *mesotype* and from *nadelstein*, and has received the designation of *Thomsonite*. Had this list proceeded from less authority in these matters than Dr. M. we should not have noticed its inaccuracies. But we consider that by thus correcting it, we are rendering a service to mineralogy.

4. *On the Pyro-electricity of Minerals.*

Haüy gave the following list of pyro-electrical minerals, with the names of those who first noticed their pyro-electrical property:

Tourmaline	*Lemery.*
Topaz	*Canton.*
Axinite	*Brard.*
Boracite, Mesotype, Prehnite, Oxide of zinc, Sphene, ...	*Haüy.*

In 1817 and the following year, Dr. Brewster took up the subject, and made many experiments relating to it; and although want of leisure prevented his extending it so far as he had originally intended, the results he has furnished us with are too interesting not to induce us to hope that he will yet find opportunities of pursuing it himself, instead of delegating it to other, and probably less able hands.

His method of determining the existence of pyro-electricity of weak intensity, in various minerals, is as follows:—"I employed the thin internal membrane of the *Arundo Phragmites*, which was cut with a sharp instrument into the smallest pieces. These minute fragments were well dried, and the pyro-electricity of any mineral was determined by its power of lifting one or more of these light bodies, after the mineral had been exposed to heat. I used also a delicate needle of brass, the pivot of which moved upon a highly polished cap of garnet, and which was affected by very slight degrees of electricity.

"In this way I determined the pyro-electricity of the following minerals:

Scolesite,*	Diamond,
Mesolite,*	Yellow orpiment,
Greenland mesotype,	Analcime,
Calcareous spar,	Amethyst,

* It is probable that the mesotype of Haüy was one or other of these two minerals.

Beryl, yellow,
Sulphate of barytes,
Sulphate of strontites,
Carbonate of lead,
Diopside,
Fluor spar, red and blue,
Quartz, dauphiny,
Idocrase,
Mellite?
Native sulphur,
Garnet,
Dichroite.

"In examining the electricity of the tourmaline, I found that it could be shown in a very satisfactory manner, by means of a thin slice taken from any part of the prism. The experiment is most advantageously performed, when the slice has its surfaces perpendicular to the axis of the prism. When such a slice is placed upon a plate of glass, and the glass heated to the temperature of boiling water, the slice will adhere to the glass so firmly, that even when the glass is above the tourmaline, the latter will adhere to it for six or eight hours. In this way, slices of a very considerable breadth and thickness are capable of supporting their own weight.

"*On the Existence of Pyro-electricity in Artificial Crystals.*

"It does not appear from any of Haüy's writings, that he even suspected the existence of pyro-electricity in crystals formed by aqueous solution. In subjecting some of these to experiment, I was surprised to find that they possessed this property, and some of them to a considerable degree. The following is a list of those in which I discovered it:

Tartrate of potash and soda,
Tartaric acid,
Oxalate of ammonia,
Oxymuriate of potash,
Sulphate of magnesia and soda,
Sulphate of ammonia,
Sulphate of iron,
Sulphate of magnesia,
Prussiate of potash,
Sugar,
Acetate of lead,
Carbonate of potash,
Citric acid,
Oxymuriate of mercury.

"Among the preceding crystals, the *tartrate of potash and soda*, and the *tartaric acid*, are pyro-electrical in a very considerable degree; but the action of several of the other salts is comparatively feeble.

"*On the Pyro-electricity of the Powder of Tourmaline.*

"Among the curious properties of artificial magnets, none is

more remarkable than that which is exhibited, by cutting a piece from one of their extremities. If the piece is taken from the north pole of the magnet, it is itself a regular magnet, with north and south polarity. The very same property was discovered in the tourmaline by Mr. Canton, who found that if it was broken into two parts, when in a state of excitation by heat, each fragment had two opposite poles.

"If we attempt, however, to reduce the magnet into minute portions by any mechanical operation, such as filing, pounding, &c. the particles of steel are found to be deprived of their magnetical qualities, their coercive power being destroyed by the vibrations or concussions which are inseparable from the process of comminution; and analogy would lead us to expect the same result with the tourmaline.

"In order to ascertain this point, I pounded a portion of a large opaque tourmaline in a steel mortar, till it was reduced to the finest dust. I then placed the powder upon a plate of glass, from which it slipped off, by inclining the glass, like all other hard powders, without exhibiting any symptoms of cohesion either with the glass, or with its own particles. When the glass was heated to its proper temperature, the powder stuck to the glass; and when stirred with any dry substance, it collected in masses, and adhered powerfully to the substance with which it was stirred. This viscidity, as it were, or disposition to form clotted masses, diminished with the heat, and at the ordinary temperature of the atmosphere, it recovered its usual want of coherence.

"Hence it follows, that the tourmaline preserves its pyro-electricity even in the state of the finest dust, and that this dust, when heated, is an universally attractible powder, which adheres to all bodies whatever."

Powdered scolezite and mesolite, after being deprived of their water of crystallization, exhibited similar pyro-electrical effects with powdered tourmaline.

"This fact," says Dr. Brewster, "is a very instructive one, and could scarcely have been anticipated. As several minerals differ only in the quantity of their water of crystallization, the powder which was thus pyro-electrical, could not be considered either as scolezite or mesolite, but as another substance not recognised in mineralogy. The pyro-electrical property, therefore, developed by the powder, cannot be regarded as a property of the minerals of which the powder formed a part, but merely as a property of some of their ingredients. In which of the ingredients, or in what combination of them, the pyro-electricity resides, may be easily determined by farther experiments." —(Edinburgh Journal of Science.)

Miscellaneous.

5. *Height of Mount Etna.*

Captain Smyth, in his lately published "Memoir of Sicily," informs us, that, according to his measurements, Mount Etna is 10,874 feet above the level of the sea, and not 12,000 feet, the height usually given to it. Prof. Schouw, in his "L'ultima cruzione dell' Etna, descrita in una lettera diretta al Cavaliere J. J. Alberto de Schœnberg, dal Dr. J. Schouw, Giornale Enciclopedico, Agosto, 1819," gives nearly the same height to the mountain; it being, according to his measurement, 10,484 French feet above the level of the sea.—(Edin. Phil. Journ.)

6. *Mediterranean.*

The medium heat of the sea around Sicily, at a depth of from 10 to 20 fathoms, by Six's thermometers is from 73° to 76°, which, being 10° or 12° warmer than the water outside Gibraltar, accounts for the greater evaporation, and consequent currents. *Smyth's Memoir of Sicily.*—(Edin. Phil. Jour.)

Article XVI.

NEW PATENTS.

R. Dickenson, Park-street, Southwark, for his improvements in the manufacture and construction of metal casks or barrels for the conveyance of goods and products by sea or otherwise.—Oct. 7.

F. Richman, Great Pulteney-street, Golden-square, carpenter, for improvements in the construction of fire-escapes.—Oct. 7.

S. Wilson, Streatham, Surry, for improvements in machinery for making velvets, and other cut works.—Oct. 7.

J. Ham, West Coker, Somersetshire, vinegar maker, for his improved process for manufacturing vinegar.—Oct. 7.

M. Bush, West Ham, Essex, calico-printer, for improvements in machinery or apparatus for printing calicoes, and other fabrics.—Oct. 7.

J. Shaw, Milltown, Derbyshire, farmer, for his transverse spring slides for trumpets, trombones, French-horns, bugles, and every other musical instrument of the like nature.—Oct. 7.

J. T. Hodgson, William-street, Lambeth, veterinarian, for certain improvements in the construction and manufacture of shoes or substances for shoes for horses and other cattle, and method of applying the same to the feet.—Oct. 7.

P. Chell, Earle's-court, Kensington, for his improvements on machinery for drawing, roving, and spinning flax, wool, waste silk, or other fibrous substances.—Oct. 14.

J. G. Bodmer, Oxford-street, Charlton-row, Manchester, civil engineer, for improvements in the machinery for cleaning, carding, drawing, roving, and spinning cotton and wool.—Oct. 14.

Article XVII.

METEOROLOGICAL TABLE.

1824.	Wind.	Barometer. Max.	Barometer. Min.	Thermometer. Max.	Thermometer. Min.	Evap.	Rain.
10th Mon.							
Oct. 1	S E	29·50	29·26	68	43	—	16
2	S	29·91	29·50	63	53	—	06
3	S	29·95	29·91	65	44	—	
4	E	29·91	29·99	65	53	—	06
5	N E	29·79	29·60	64	45	—	09
6	E	29·60	29·45	64	47	—	37
7	S W	29·49	29·45	56	45	—	15
8	S W	29·65	29·49	69	52	—	
9	W	29·70	29·65	63	48	—	
10	E	29·68	29·11	53	47	—	53
11	S E	29·11	29·05	60	43	—	12
12	N E	29·52	29·05	55	37	—	11
13	N W	29·75	29·52	45	28	—	
14	N W	29·82	29·75	50	29	—	
15	N W	30·05	29·82	48	28	—	—
16	N W	30·19	30·05	48	26	—	
17	W	30·31	30·19	50	25	—	—
18	W	30·31	30·28	50	35	·80	
19	S W	30·28	30·18	52	31	—	—
20	W	30·18	30·16	56	36	—	
21	S E	30·16	30·10	60	36	—	
22	S E	30·10	30·07	61	51	—	
23	N W	30·07	30·03	62	45	—	
24	S E	30·03	29·72	63	53	—	—
25	S W	29·72	29·45	61	50	—	17
26	W	29·66	29·45	57	37	—	—
27	W	29·84	29·66	58	37	—	
28	W	29·85	29·84	55	48	—	
29	N E	30·05	29·85	55	40	—	27
30	W	30·18	30·05	48	35	—	
31	S W	30·18	29·82	50	45	—	28
		30·31	29·05	69	25	·80	2·37

The observations in each line of the table apply to a period of twenty-four hours, beginning at 9 A. M. on the day indicated in the first column. A dash denotes that the result is included in the next following observation.

REMARKS.

Tenth Month.—1. Rainy. 2. Showers. 3, 4. Fine. 5, 6. Rainy. 7. Rainy: a very distinct lunar rainbow at eight, p. m. 8. Fine: a lunar corona. 9. Fine. 10—12. Rainy. 13, 14. Fine. 15. Foggy morning: drizzly afternoon. 16. White frost: fine. 17. Ditto. 18. Foggy morning: fine. 19. Cloudy and fine. 20, 21. Fine. 22, 23. Cloudy. 24. Fine. 25. Cloudy. 26. Showers. 27, 28. Fine. 29. Rainy. 30. Fine. 31. Rainy.

RESULTS.

Winds: NE, 3; E, 3; SE, 5; S, 2; SW, 5; W, 8; NW, 5.

Barometer: Mean height

For the month	29·803 inches.
For the lunar period, ending the 15th	29·611
For 14 days, ending the 5th (moon south)	29·864
For 14 days, ending the 19th (moon north)	29·732

Thermometer: Mean height

For the month	49·111°
For the lunar period	52·689
For days, the sun in Libra	49·350
Evaporation	0·80 in.
Rain	2·37

Laboratory, Stratford, Eleventh Month, 23, 1824. R. HOWARD.

INDEX.

ABERTHAW limestone, analysis of, 72.
Academy of Sciences, proceedings of, 227.
Acetates of copper, on the composition of, 188.
Acids and alkalies, juice of elder berries a test of, 384.
—— free, on the nature of that ejected from the human stomach, 68.
—— fluoric, on, 330, 450.
—— ——— double salts of, 339.
—— ——— saturating capacity of, 338.
—— prussic, effect of, on vegetation, 304.
—— iodous, properties of, 386.
—— sulphurous, anhydrous, on the production of, 307.
Adelmann, M. description of an improved goniometer, 212.
Aërial excursion, observations made during a late one, 209.
Æther, notice respecting, 286.
Air pump, account of a new one, 255.
Alcohol, method of employing, in vegetable analysis, 387.
Alkalies and acids, juice of elder berries as a test of, 384.
Alumina, fluate of, 334.
——— and soda, fluate of, 341.
American localities of minerals and fossils, 312, 391.
Ammonia, fluate of, 333.
Ampere and Dulong, MM. abstract of their memoir on M. Rousseau's memoir on a new method of measuring the powers of bodies to conduct electricity, 39.
Analysis of the red silver ore, 29.
——— vegetable, method of employing alcohol in, 387.
Antimony, fluates of, 337.
——— tartarized, composition of, 151.
Arfwedsonite, characters of, before the blowpipe, 37.
Ascension, Right, corrections of 37 principal stars of the Greenwich catalogue, 23, 248.

B.

Baily, Mr. notice of his paper on the occultation of the Georgium Sidus by the moon, 146.
Baize and flannel trade, extent of, 316.
Barytes, fluate of, 333.
Baryto-calcite, on, 114—analysis of, 115.
Battley, M. on his method of preparing morphia, 343.
Beaufoy, Capt. account of some observations made during a late aërial excursion, 209.
——— Col. astronomical observations by, 11, 141, 286, 329, 419—remarks on the construction of vessels, 264.
Becker, M. on the effect of prussic acid on vegetation, 304.
Becquerel, M. abstract of his paper on electromotive actions produced by the contact of metals with liquids, &c. 42.
Berzelius, M. on the results of some chemical analyses, and the decomposition of silica, 121—on the mineral waters of Carlsbad, 123—on inodorous hydrogen gas, 153—analysis of a new lead ore, 154—on the inflammation of sulphuretted hydrogen by nitric acid, 151—on the combinations of acetic acid with peroxide of copper, 188—on the distinction of positive and negative electricity, 236—on fluoric acid, and its most remarkable combinations, 330, 450—analysis of the sulphato-tricarbonate of lead, 467.
Breant, M. on a process for making damasked steel, 267.
Brewster, Dr. on surfaces composed of siliceous filaments, incapable of reflecting light, 236.
Books, analysis of, 60, 144.
——— new scientific, 77, 157, 237, 318, 398.
Bonsdorff, M. analysis of the red silver ore, 29.
Bostock, Dr. on the applicability of Sir H. Davy's discovery to copper vessels employed for culinary purposes, 176.
Brochantite, a new mineral substance, on, 241—chemical examination of, 243.
Brooke, M. on baryto-calcite, 114.
Bussy, M. on the sulphuric acid of Saxony, 259—on the production of anhydrous liquid sulphurous acid, 307.

C.

Cabbage, red, to preserve the colour of, 304.

Cadmium, fluate of, 335.
Calculi, on a new method of destroying them, 396.
Calculus, urinary, description of, 152.
Camphor, on the cause of its rotatory motion in water, 75.
Carlsbad, on the mineral waters of, 123.
Chalybeate preparations of the London Pharmacopœia, composition of, 149.
Celery, manna in the leaves of, 385.
Cerium, fluates of, 336.
Children, Mr. on the characters of some mineral substances before the blowpipe, 36—chemical examination of barytocalcite, 115—reply to an erroneous statement respecting Sir H. Davy's method of defending the copper sheeting for ships' bottoms, 141—chemical examination of brochantite, 245—on the mistatements respecting Sir H. Davy's method of protecting the copper sheeting of ships' bottoms, 362—chemical examination of rosélite, 441.
Chilton, Mr. description of an improved rain gauge, 109.
Clarke, Rev. E. D. biographical notice of, 401.
Chloride of lime, instructions for the assay of, 218.
Chromium, fluates of, 336, 337.
Chrysoberyls, American and Brazilian, analyses of, 305.
Cinnamon stone, analysis of, 310.
Clocks, improvement in, 76.
Cobalt, fluate of, 335.
Columbite of Haddam, account of, 359.
Conybeare, Rev. J. J. biographical sketch of, 162.
Copper, acetates of, on the composition of, 188.
——— fluate of, 335, 336.
——— metallic, soluble in ammonia, 77.
——— peroxide of, organic analysis by, 308.
——— sheeting, on the method of preventing the corrosion of, 94.
——— vessels, on the applicability of Sir H. Davy's discovery to, 177.
Corrosion of copper sheeting, and the method of preventing, 94.
Cumming, Rev. Mr. on the use of gold leaf as a test of electromagnetism, 321.
Crystals, contraction of, by heat, 393.
——— artificial, pyro-electricity of, 469.
Cystic oxide, on the, 146.

D.

Dana, Mr. on the use of nitrous gas in eudiometry, 149.
Daniell, Mr. remarks on his work on hygrometry, 215.
Daniell, Mr. reply to the remarks of X, 257, 439.
——— reply to him by X, 348.
Daphne, alkali of, on the, 305.
Davies, Mr. on an application of mathematics to chemical analysis, 99.
Davy, Sir H. on the corrosion of copper sheeting by sea water, and the method of preventing, 94—defence of his method of defending copper sheeting, 141—reply to the mistatements respecting his method of copper sheeting, 362.

E.

Edinburgh, rare minerals found in the vicinity of, 156.
Elder berries, juice of, as a test, 384.
Electricity, abstract of a memoir on a new method of measuring the powers of bodies to conduct, 39.
——— on the transmission of, through tubes of water, 48, 116.
——— produced by the congelation of water, 157.
——— positive and negative, distinction of, 236.
Electric current, on certain motions produced by, in fluid conductors, 170, 271.
Electromagnetic effects, mode of employing them to ascertain the change which certain solutions undergo by contact with the air, 42.
Electromagnetism, on the use of gold leaf as a test of, 321.
Emmett, Rev. Mr. on an anomaly presented by the combination of potassium and oxygen, &c. 205—on the expansion of liquids, 254.
Engine, explosive, account of, 157.
——— steam, on the advantages, &c. of high, mean, and low pressures, 357.
Erlanite, a new mineral, description of, 389.
Etna, Mount, height of, 472.
Eudiometry, on the use of nitric oxide in, 149.
Expansion of liquids, on the, 254.
Explosive engine, account of, 157.

F.

Faraday, Mr. examination of taschium, 149.
Fayerman, Dr. on the use of acetate of lead in hydrophobia, 232.
Fitton, Dr. inquiries respecting the geological relations of the beds between the chalk and the Purbeck limestone series in the south-east of England, 365—notice of his paper on the geology of the

coasts of the English Channel, &c. 67—additions to his paper on the Isle of Wight, 458.
Fluate of potash, 332—soda, 332—lithia, 333—ammonia, 333—barytes, 333—strontian, 334—lime, 334—magnesia, 334—glucina, 334—yttria, 334—alumina, 334—zirconia, 334—oxidule of manganese, 335—oxide of manganese, 335—oxidule of iron, 335—oxide of iron, 335—zinc, 335—cadmium, cobalt, nickel, and copper, 335—oxidule of copper, oxidule and oxide of cerium, lead, oxide of chromium, 336—oxidule of chromium, antimony, tin, uranium, silver, mercury, platinum, 337.
——— silica, composition of, 455.
——— soda and alumina, 341.
Fluoric acid, on, 330.
——— saturating capacity of, 338.
Fowling pieces, on fulminating powders used as a priming for, 395.
Fraser, Mr. notice of his paper on the geology of the province of Khorosan, in Persia, 65.
Fulminating powders employed as priming for fowling pieces, 395.

G.

Gahn, J. G. biographical account of, 1.
Garnets, analysis of various, 388.
Gas, hydrogen, inodorous, 153, 229.
Gay-Lussac, instructions for the assay of chloride of lime, 218—on paratonnerres, or conductors of lightning, 427.
Glucina, fluate of, 334.
Gmelin, M. analysis of tourmaline, 73.
——— Dr. analysis of pirite, 309.
Gobel, Dr. on the composition of tartarized antimony, 151.
Gompertz, Mr. notice of his paper on the differential sextant, 145.
Goniometer, description of an improved one, 212.
Gray, Mr. on the arrangement of the papilonidæ, 119—on the natural arrangement of the pulmonobranchous mollusca, 107.
Gunpowder, on the heat produced by firing of, 245.

H.

Hare, Dr. electromagnetic and galvanic experiments by, 317.
Haycraft, Mr. on the heat produced by firing gunpowder, and on the intense heat of blast furnaces, 245.
Heat, minerals produced by, 467.
—— on that produced by firing gunpowder, and that of blast furnaces, 245.
Heat, unequal distribution of, in the prismatic spectrum, 235.
Henry, Dr. experiments on the analysis of some of the aeriform compounds of nitrogen, 299, 344.
Herapath, Mr. on the solution of $\psi^n x = x$, 322, 420.
Herschel, Mr. on certain motions produced in fluid conductors when transmitting the electric current, 170, 271.
Hissinger, M. analysis of various garnets, 388.
Howard, Mr. meteorological table, 78, 150, 239, 319, 399.
Hydrogen gas, inodorous, 153, 229.
——— and oxygen, inflammation of a mixture of, under water, 387.
——— sulphuretted, inflammation of, by nitric acid, 151.
Hydrophobia cured by acetate of lead, 232.
Hydrophosphoric gas, ignition supported by, 304.

I.

Ignition supported by hydrophosphoric gas, 304.
Iron ore, argillaceous, analysis of, 72.
—— oxide and oxidule of, fluate of, 335.
Iodine and phosphorus, action of, 154.

K.

Kirkdale cave, observations on Mr. Penn's theory of the formation of, 50.

L.

Labillardiere, M. on the Lillebonne statue, 102.
Lassaigne, M. on the means of detecting the presence of morphia, &c. 228.
Latrobite, characters of, before the blowpipe, 38.
Laugier, M. analysis of a urinary calculus, 152.
Lead, fluate of, 336.
—— ore, new one, analysis of, 154.
—— sulphato-tricarbonate of, analysis of, 467.
Leather, tanning of, on the best method of chemically ascertaining the value of the different articles used for, 180.
Leuthwaite, Mr. on the transmission of electricity through tubes of water, 116.
Lenzinite, description and analysis of, 391.
Lévy, M. on a new mineral substance, 241, 439.
Lewenau, M. on the extraction of selenium from the sulphureous deposits left

in the manufacture of sulphuric acid, 104.
Light and heat, solar, remarks on, 81, 287.
——— from terrestrial sources, on, 181.
Lightning, conductors of, instructions respecting, 427.
Lillebonne, analysis of the statue found at, 101.
Lime, chloride of, instructions for the assay of, 218.
—— fluate of, 334.
—— and magnesia, method of estimating the quantities of, 99.
—— oxalate of, decomposed by potash, 309.
—— silicated fluate of, composition of, 455.
Liquids, expansion of, on the, 254.
Limestone, Aberthaw, analysis of, 72.
Lithia, fluate of, 333.

M.

Mac Culloch, Dr. notice of his paper on the possibility of changing the residence of certain fishes, 394.
Magnesia and lime, method of saturating the quantities of, 99.
——— fluate of, 334.
Manganese, oxidule and oxide, fluates of, 335.
——— peroxide of, composition of, 225.
Manna, existence of, in the leaves of celery, 385.
Marobia, description of, 398.
Massotti, M. notice of his paper on the variation of the mean motion of the comet of Encke, 145.
Mathematics, application of, to chemical analysis, 99.
Mediterranean, temperature of, 472.
Meionite, analysis of, 389.
Mercury, fluates of, 337.
Meteorological table, 78, 150, 239, 319, 399, 473.
Mines, temperature of, on the, 446.
Minerals and fossils, American localities of, 312, 391.
——— produced by heat, 467.
——— pyro-electricity of, 469.
——— rare, found in the vicinity of Edinburgh, 156.
——— Scotch, localities of, 468.
——— Vesuvian, notice of, 392.
Mitscherlich, Prof. on the contraction of crystals by heat, 393—on the production of minerals by heat, 467.
Mollusca, pulmonobranchous, on the natural arrangement of, 107.
Morphia, on the means of detecting the presence of, 228.
——— on Mr. Battley's method of preparing, 343.
Moyle, on the temperature of mines, 446

N.

Nerves, optic, on semi-decussation of, 294.
Nickel, fluate of, 335.
Nitrogen, aeriform compounds of, analyses of, 299, 344.
Nordhausen, sulphuric acid of, on the, 259.

O.

Observations, astronomical, 11, 141, 286, 329, 419.
Optic nerve, on semi-decussation of, 294.
Optical axes of crystals, on the inclination of the line dividing the, 393.
Oxalate of lime decomposed by potash, 309.
Oxide, cystic, on the, 146.
——— nitric, on the use of, in eudiometry, 149.
——— of manganese, composition of, 225.
Oxygen and hydrogen, inflammation of a mixture of, under water, 387.

P.

Papilonidæ, on the arrangement of, 119.
Paratonnerres, or conductors of lightning, instructions respecting, 427.
Patents, new, 78, 158, 238, 318, 393, 472.
Patten, Mr. on a new air pump, 255.
Penn, Mr. observations on his theory concerning the formation of the Kirkdale cave, 50.
Pepper, black, on zirconia in, 149.
Petalite, discovery of, on Lake Ontario, 73.
Pfaff, C. H. on the deoxidizing property of the vapour of water, 45.
Phillips, R. analysis of argillaceous iron ore, 72—of Aberthaw limestone, 72—composition of the chalybeate preparations of the London Pharmacopœia, 149.
——— ——— answer to his observations on the London Pharmacopœia, 463.
Phosphorus and iodine, action of, 154.
Phosphuretted hydrogen, on the composition of, 213.
——— ——— ——— gas, on, 247.
Pinite, analysis of, 309.

Platinum, fluate of, 337.
Potash, fluate of, 332.
Potash, silicated fluate of, composition of, 455.
Potassium and oxygen, on an anomaly presented by the combination of, 205.
Powell, Mr. remarks on solar light and heat, 81, 287—on light and heat from terrestrial sources, 156, 181.
Prismatic spectrum, unequal distribution of heat in, 235.
Prout, Dr. on the nature of the acid of saline matters usually existing in the stomachs of animals, 117.
Prussic acid, effect of, on vegetation, 304.
Pyroacetic spirit, on the properties of, 69.
Pyro-electricity of minerals, and artificial crystals, 469.
Pyroxylic spirit, on the properties of, 69.

R.

Rain gauge, description of an improved one, 109.
Rochdale, extent of baize and flannel trade at, 316.
Rousseau, M. report of his memoir on a new method of measuring the powers of bodies to conduct electricity, 39.

S.

Sahlite, singular form of crystals of, 310.
Salts, double, of fluoric acid, 339.
Sandstone, old red, remarks on, 11.
Scrope, Mr. notice of his paper on the geology of the Ponza island, 65.
Selenium, on the extraction of, from the sulphureous deposits left in the manufacture of sulphuric acid from pyrites, 104.
——— discovery of, in the volcanic rocks of Lipari, 156.
——— an attendant of sulphur, 230.
Sementini, M. on iodous acid, 386.
Seybert, Mr. analyses of chrysoberyls, 315.
Silica, fluate of, composition of, 455.
—— on the decomposition of, 121.
Sillimanite, description of, 315.
Silver, fluate of, 337.
—— ore, red, analysis of, 29.
Society, Astronomical, proceedings of, 64, 145.
——— Geological, proceedings of, 65, 465.
——— Linnean, proceedings of, 63, 464.
——— Royal, proceedings of, 63, 464.
Smithson, Mr. observations on Mr. Penn's theory concerning the formation of the Kirkdale cave, 50.
Soda and alumina, fluate of, 341.
—— fluate of, 332.
—— silicated fluate of, composition of, 455.
Solutions, changes which certain, undergo by contact with the air, ascertained by electromagnetism, 42.
South, Mr. corrections in right ascension of 37 principal stars of the Greenwich catalogue, 23, 248.
——— Mr. W. on Mr. Battley's method of preparing morphia, 343.
Spirit, pyroacetic, on the properties of, 69.
——— pyroxylic, on the properties of, 69.
Sprudelstones, analysis of, 140.
Stars, right ascension of 37, corrections in, 23, 248.
Steam-engines, on the advantages of high, mean, and low pressure, 351.
Steel, damasked, process for making, 267.
Stomachs of animals, on the nature of the acid and saline matters usually existing in, 117.
——— on the nature of the free acid ejected from, 68.
Strontian, fluate of, 334.
Strychnia, salts of, volatility of, 384.
Substances, mineral, on the characters of some, before the blowpipe, 36.
Subphosphuretted hydrogen gas, on, 247.
Sulphates of uranium, native, description of, 390.
Sulphuric acid of Saxony, on the, 259.
Sulphurous acid, anhydrous liquid, on the production of, 307.
Surfaces, incapable of reflecting light, on, 236.

T.

Table, meteorological, 78, 150, 239, 319, 399, 473.
Tallow, mountain, properties of, 155.
Taschium, a supposed new metal, examination of, 149.
Tellurium, new locality of, 231.
Thomson, Dr. reply to M. Vauquelin's remark on a supposed contradiction in his System of Chemistry, 203—on subphosphuretted hydrogen gas, 247.
Tide, extraordinary one, 234.
Tin, fluate of, 337.
Topham, Rev. J. analysis of his Epitome of Chemistry, 60.
Torry, Dr. on the columbite of Haddam, 359.
Tourmaline, composition of, 73.
Traill, Dr. on the action of iodine and phosphorus, 154.
Trinkets, gold, method of cleaning, 76.

U. and V.

Van Mons, M. on ignition supported by hydrophosphoric gas, &c. 304.
Vapour of water, on the deoxidizing property of, 45.
Vauquelin, M. analysis of the metal of the statue found at Lillebonne, 101—on a contradiction in Thomson's System of Chemistry, 147—on the alkali of the Daphne, 305.
Vegetable alkalies, volatility of some of, 384.
Vessels, on the construction of, 264.
Vesuvian minerals, notice of, 392.
Uranium, fluate of, 337.
——— sulphates of, description of, 390.

W.

Water, congelation of, electricity produced by, 157.
——— vapour of, on the deoxidizing property of, 45.
Weaver, T. additional remarks on the older red sandstone formation, &c. 11.
Webster, Dr. an account of new localities of American minerals, 73.
——— Mr. on the Isle of Wight, 463.
——— notice of his paper on, 466—on the Purbeck and Portland beds, 467.
Whipple, Mr. on nitric ether, 286—answer to Mr. Phillips's observations on the London Pharmacopœia, 463.
Wight, Isle of, additions to Dr. Fitton's paper, on, 458.
Wollaston, Dr. on semi-decussation of the optic nerves, 294.
Woodward, Mr. on the transmission of electricity through tubes of water, 48.

X.

X.'s remarks on Mr. Daniell's work on Hygrometry, 215—reply to Mr. Daniell's observations, 257, 348.

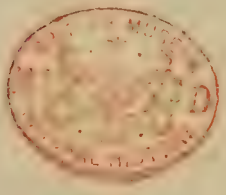
Y.

Yttria, fluate of, 334.

Z.

Zinc, fluate of, 334.
Zirconia, fluate of, 334.
——— in black pepper, 149.

END OF VOL. VIII.



Printed by C. Baldwin, New Bridge-street, London.